ASSESSMENT OF NEUROSENSORY RECOVERY FOLLOWING ORTHOGNATHIC SURGERY – A PROSPECTIVE STUDY

Dissertation submitted to

THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY

Towards the partial fulfillment for the degree of

MASTER OF DENTAL SURGERY

BRANCH-III

ORAL AND MAXILLOFACIAL SURGERY

APRIL - 2011

CERTIFICATE

This is to certify that **Dr.T.GURU PRASAD***, P.G. Student (2008-2011) in the Department of Oral and maxillofacial surgery, Tamilnadu Government Dental College and Hospital, Chennai-600 003, has done* dissertation *titled "***Assessment of Neurosensory Recovery Following Orthognathic Surgery – A Prospective Study"** *under our direct guidance and Supervision in partial fulfillment of the regulation laid down by The Tamilnadu Dr.M.G.R. Medical University, Chennai, for MDS, Branch-III, Oral and Maxillofacial Surgery Degree Examination.*

Guide & HOD:

Prof. G.UMA MAHESWARI MDS
Professor and Head of the Department
Department of Oral and Maxillofacial surgery
The Tamilnadu Government Dental College
Chennai.

Prof. Dr.K.S.G.A NASSER M.D.S.,
Principal
The Tamilnadu Govt. Dental College
& Hospital,
Chennai – 600 003.

ACKNOWLEDGEMENTS

I am greatly indebted to ***Prof. Dr. G.Uma Maheswari M.D.S,*** *Professor and HOD, Department of Oral & Maxillofacial Surgery, Tamilnadu Govt Dental College and Hospital for teaching me the art of surgery during the period of my study. Words cannot express the contribution and relentless encouragement given by this humble and luminous soul, to whom I will be obliged forever.*

I express my sincere thanks to ***Prof. Dr.B.Saravanan M.D.S,*** *Professor, Department of Oral and Maxillofacial Surgery, for his valuable guidance, encouragement, lending me their precious time for the successful completion of this study and throughout my post graduation period.*

I am very much grateful to ***Prof. Dr.C.Durairaj, M.D.S.,*** *Professor, Department of Oral & Maxillofacial Surgery for his unrestricted help and advice throughout the study period.*

I offer with profound respect and immense gratitude my heartfelt thanks to ***Prof. Dr. K.S.G.A Nasser M.D.S,*** *Principal, Tamilnadu Govt Dental College and Hospital, for his constant encouragement and support throughout my endeavour during my post graduation period.*

*I express my sincere thanks to****, Dr. Appadurai M.D.S , Dr. Sethurajan M.D.S, and Dr.Vinayagam M.D.S*** *Assistant Professors in the Department of Oral and Maxillofacial Surgery, Tamilnadu Govt Dental College and Hospital for their timely suggestion during course of the study.*

*I express my special thanks to **Dr. Appadurai M.D.S** my co-guide for helping me and providing me timely advice during my study period and thereafter.*

*I would like to give special thanks to my colleague **Dr. D. Karthikeyan,** to whom, I have no words to express my gratitude, who has stood with me at times of need and always, and to all my colleagues who supported me for the same.*

I would like to extend my gratitude to the Dept of Orthodontics for providing me with patients and their invaluable assisstance during the course of this study.

Narrow border of language could never express my respect and gratitude to all the patients who co-operated with me for this study.

I dedicate this study to my parents, for their unconditional love and concern.

*Last but not the least I would like to seek the **blessings of the Almighty** without whose grace this endeavour wouldn't have been possible*

DECLARATION

I, **Dr.*T.GURU PRASAD***, do hereby declare that the dissertation titled "**ASSESSMENT OF NEUROSENSORY RECOVERY FOLLOWING ORTHOGNATHIC SURGERY – A PROSPECTIVE STUDY"** was done in the Department of Oral and Maxillo Facial Surgery, Tamil Nadu Government Dental College & Hospital, Chennai 600 003. I have utilized the facilities provided in the Government dental college for the study in partial fulfillment of the requirements for the degree of **Master of Dental Surgery** in the speciality of Oral and Maxillo Facial Surgery **(Branch III)** during the course period **2008-2011** under the conceptualization and guidance of my dissertation guide**, Prof. Dr. G. UMA MAHESWARI, MDS.**

I declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Tamil Nadu Government Dental College & Hospital.

I also declare that no part of this work will be published either in the print or electronic media except with those who have been actively involved in this dissertation work and I firmly affirm that the right to preserve or publish this work rests solely with the prior permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai 600 003, but with the vested right that I shall be cited as the author(s).

Signature of the PG student

Signature of Guide & Head of the department

Signature of the Head of the Institution

CONTENTS

INSTITUTIONAL ETHICAL COMMITTEE

Tamil Nadu Government Dental College and Hospital, Chennai-3

Telephone No : 044 2534 0343
Fax : 044 2530 0681

R.C.No. 0430/DE/2010 Date : 26.11.2010

Title of the Work : Neurosensory recovery following Orthognathic Surgery

Principal Investigator: Dr.Guru Prasad, Final Year PG Student

Department : Dept of Oral & Maxillofacial Surgery
Tamil Nadu Govt Dental College and Hospital, Chennai-3

The request for an approval from the Institutional Ethical Committee (IEC) was considered for the following on the IEC meeting held on 18.10.2010 at the Principal's Chamber, Tamil Nadu Government Dental College & Hospital, Chennai-3.

"Advised to Proceed with the Study"

The Members of the Committee, the Secretary and the Chairman are pleased to approve the proposed work mentioned above, submitted by the Principal Investigator.

The Principal Investigator and their team are directed to adhere the guidelines given below:

1. You should get detailed informed consent from the patients/participants and maintain confidentiality.
2. You should carry out the work without detrimental to regular activities as well as without extra expenditure to the Institution or Government.
3. You should inform the IEC in case of any change of study procedure, site and investigation or guide.
4. You should not deviate from the area of work for which you have applied for ethical clearance.
5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the Institution.
6. You should complete the work within the specific period and if any extension of time is required. You should apply for permission again and do the work.
7. You should submit the summary of the work to the ethical committee on completion of the work.
8. You should not claim funds from the Institution while doing the work or on completion.
9. You should understand that the members of IEC have the right to monitor the work with prior intimation.
10. Your work should be carried out under the direct supervision of your Guide/Professor.

S Jayachand 26/11/10 [illegible] 26/11/10

SECRETARY **CHAIRMAN**

INTRODUCTION

"*Personal beauty is a greater recommendation than any letter of reference*."

-Aristotle

Physical beauty, beyond doubt is a highly-valued quality throughout the world. ***Physiognomy***[13], the art of judging people's character from facial features, also contributes to our obsession with appearance.

Dr. Stephen R. Marquardt, however, attempted to quantify beauty scientifically by developing the Golden Decagon Mask. This two-dimensional visual of the human face is based upon the Golden Ratio (also known as the Divine or phi ratio): 1:1.618. The closer a face is to this template, the more aesthetically pleasing the face is. Now, many plastic surgeons use this model when enhancing their patients' facial features.

Establishment of a universal standard for facial beauty will significantly simplify the diagnosis and treatment of facial disharmonies and abnormalities. More important, treating to this standard will maximize facial esthetics, TMJ health, psychologic and physiologic health, fertility, and Quality of life.

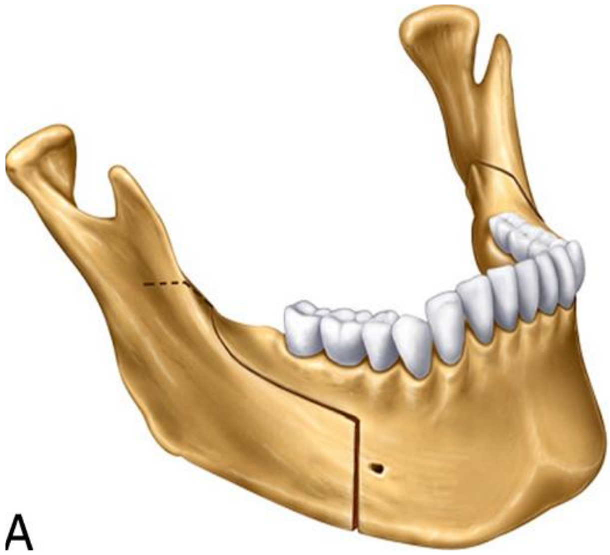
Facial asymmetries can occur unilaterally or bilaterally in any or all spatial planes of growth, i.e, horizontal, vertical and transverse causing discrepancies in size/ position of the jaws. For this reason the specialty of maxillofacial surgery which deals with repositioning of the jaws (Orthognathic Surgery) is often necessary.

. Surgical repositioning of the skeletal components of the facial structure can be used to improve function[61] and aesthetics[30]. An extensive number of osteotomies are performed within the maxillofacial region to fulfill these purposes. The most commonly administered of these are the Le Fort osteotomy of the maxilla, the Bilateral Sagittal Split Ramus Osteotomy (BSSRO) and Intraoral Vertico-Sagittal Ramus Osteotomy (IVSRO) of the mandibular ramus, and Genioplasty of the chin and Segmental Osteotomies of the maxilla and mandible.

There has been a proliferation of such treatments owing to the increasing desire to improve appearance and resolve functional deficits, such as difficulties in mastication and speech. Various benefits have been reported, including improved masticatory function, reduced temporomandibular joint pain, and improved facial aesthetics. However, as the number of surgical performances increases, numerous complications[36] such as vascular problems, temporomandibular joint problems, nerve injuries, and infections have also been reported more frequently. Neurosensory deficits[72] have been reported to be the most common problem following orthognathic surgery.

AIM OF THE STUDY

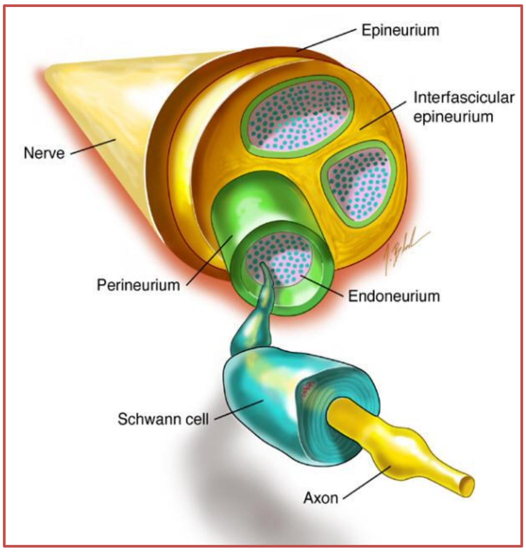
The aim of this prospective study is to assess the Neurosensory and Somatosensory functions and recovery following Orthognathic surgery (Bilateral Sagittal Split Osteotomy, Segmental osteotomy and Genioplasty, using rigid fixation under General anaesthesia.



SURGICAL ANATOMY

The NERVOUS SYSTEM is the most complicated and highly organized of the various systems which make up the human body. It is concerned with the correlation and integration of various bodily processes and the reactions and adjustments of the organism to its environment. It may be divided into two types, **Central and Peripheral**. A brief review of the anatomy and physiological considerations of the peripheral nerve and ganglia is necessary to understand, the nature of injury, its severity and to arrive at the clinical diagnosis and management.

The trigeminal nerve is composed of a Mesoneurium that suspends the nerve within the surrounding tissues and is continuous with the outer Epineurium that defines and surrounds the nerve trunk. The Epineurium is divided into outer and inner layer, and the inner layer is composed of a loose connective tissue sheath with longitudinal collagen bundles that protect the nerve, against compression and stretching forces imposed on the nerve.



Individual fascicles are defined by the Perineurium which is a continuation of the pia arachnoid layer of the central nervous system. It functions to provide structural support and acts as a diffusion barrier. The individual nerve fibers and Schwann cells are surrounded by the Endoneurium, which is composed of collagen, fibroblasts and capillaries.

There are three types of neural fascicular patterns;

i) Mono fascicular,

ii) Oligo fascicular

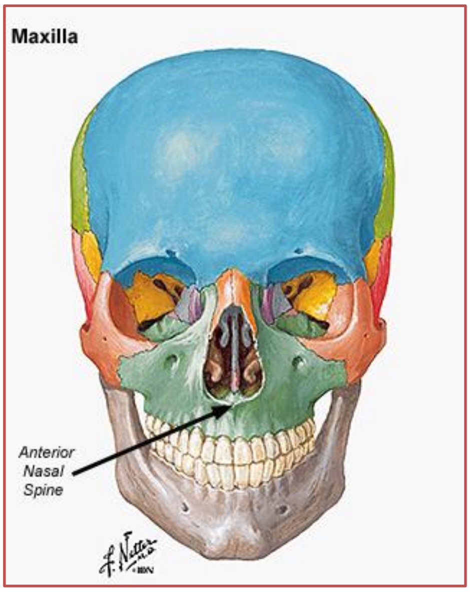
iii) Poly fascicular.

The Inferior alveolar and Lingual nerves are Polyfascicular[46] in nature, the importance of which is that needle penetrations rarely causes direct neural trauma and also nerve repair with realignment of fascicles is challenging.

Fibere	Size (μ)	Conduction velocity (m/s)	Function
Aα(myelin)	12-20	70-120	Position, fine touch
Aβ(myelin)	6.0- 12	35-170	Proprioception
Aδ(thin myelin)	1.0-6.0	2.5-3.5	Superficial pain, Temperature
C(unmyelinated)	0.5- 1.0	0.7- 1.5	Deep pain, Temperature

The peripheral nerve is composed of differing fibre types, which transmit a variety of information. The Aα (alpha- militated) fibers are the largest fibers with fastest conduction velocity; they mediate position and fine touch through muscle spindle afferents and skeletal muscle efferents. The Aβ (beta- myelinated) fibers mediate proprioception. The smallest fibers are the Aδ (delta-myelinated) fibers, which carry pain and temperature information. The smaller diameter and slower- conducting unmyelinated C fibers mediate “second” or “slow” pain and temperature sensations.

The osseous structures that support the teeth are the Maxilla and the Mandible. A description of the maxilla and the mandible must include, normally developed osseous framework, encompassing the teeth in their complete dental arches. This establishes the teeth as, foundation tissues for jaw growth, support and as a part of the framework of the face. The root forms, with their size and angulation, will govern the shape of the alveoli in the jaw bones, and this in turn shapes the contour of the dento-osseous portions facially.



The maxilla constitutes a large part of the bony framework of the facial portion of the skull.In the frontal view, the two maxillae form the border of the piriform aperture and inferior and medial border of the orbit. The body of the maxilla contains the Maxillary

Sinus (Antrum of Highmore), which defines the anterior surface and the canine fossa just above the alveolar process. Above the canine fossa and slightly below the infraorbital rim the infraorbital foramen is located between 8 and 20 mm from the nasal floor. . The maxillary height is correlated to the height of the infraorbital foramen. The vascular and neural contents of the infraorbital canal supply the blood flow and sensation to the cheek, the upper lip and the lateral aspect of the nose.

The maxillary tuberosity defines the posterior border of the maxilla and the pterygomaxillary fissure lies between the maxillary tuberosity and pterygoid plates of sphenoid bone. This anatomic landmark is important in the pterygomaxillary dysjunction during Lefort I osteotomy because the descending palatine artery is located medially within 10 mm from the maxillary tuberosity, as the osteotome is driven anteriorly and medially, through the pterygomaxillary articulation. During osteotomy of the lateral nasal wall, care is taken to extend the osteotomy no farther than 25 to 30 mm posteriorly from the piriform rim.

The maxillary nerve, second division of the fifth cranial nerve, runs forward on the wall of the cavernous sinus and leaves the skull through the Foramen Rotundum. It crosses the pterygopalatine fossa where it gives branches to the pterygopalatine (a parasympathetic) ganglion. This ganglion gives off several branches, containing visceral motor as well as sensory fibres to the mucous membrane of the mouth, nose and pharynx.

The branches of clinical significance are, The Palatine Branches. The Anterior Palatine nerve enters the hard palate through the major palatine foramen to be distributed to the hard palate and palatal gingivae as far as the canine tooth. The Middle and the Posterior Palatine branches from the ganglion, supplies the soft palate and the tonsil through the minor palatine foramina. The Nasopalatine branch runs downward and forward on the nasal septum, entering the palate through the incisive canal.

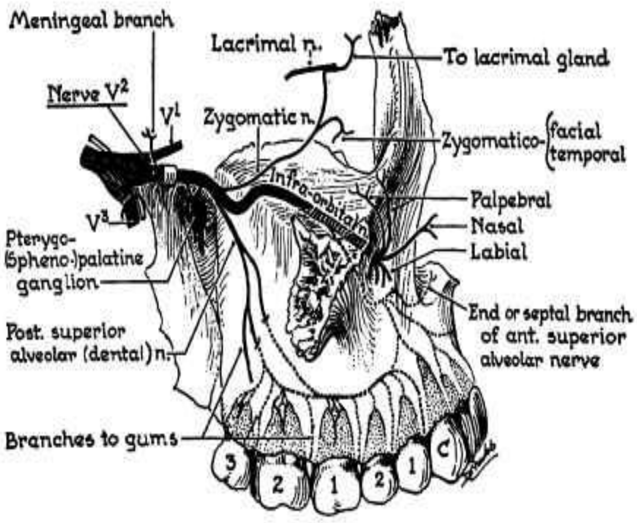


FIG. 795. Distribution of the maxillary (V2) nerve

The Maxillary nerve gives off Posterior Superior Alveolar branch from the Pterygopalatine ganglion that , divides , and enters the posterior surface of the maxilla, forming a plexus, distributed to the molar teeth and supporting tissues. The maxillary nerve continues as the Infraorbital nerve, enters the orbit, runs forward in its floor first in the infra orbital groove, then in the canal, terminating in the infraorbital foramen, supplying the skin of the middle third of the face. At a variable distance after it enters the orbit, a Middle Superior Alveolar Branch arises from the infraorbital nerve and runs through the lateral wall of the maxillary sinus. It is distributed to the premolar teeth and surrounding tissues and joins the alveolar plexus. An Anterior Superior Alveolar branch leaves the infraorbital nerve just inside the infraorbital foramen and is distributed through bony canals to the incisor and canine teeth. All these superior alveolar nerves join in a plexus, from which dental branches are given off to each tooth and interdental branches to the bone, periodontal membrane and gingivae.

The Mandible is a horse shoe shaped bone, and supports the teeth of the lower dental arch. The mandible has a horizontal portion, (or body) and two vertical portions, (or Rami). The rami join the body at an obtuse angle. The External oblique ridge extends obliquely across the external surface of the mandible from the mental tubercle to the anterior border of the ramus.

An important landmark on the external aspect of the mandible is the Mental Foramen, opening upward, backward and laterally. The foramen is usually located midway between the superior and inferior border of the body of the mandible, between the first and second premolars, a little below the apex of the roots.

The mandibular foramen is located on the medial surface of the ramus midway between the sigmoid notch and the angle of the mandible between the internal oblique line and posterior border of the ramus. The foramen continues as the mandibular canal, runs downward and forwards horizontally. The anterior margin of the foramen is marked by the Lingula or the mandibular spine, which gives attachment to the Sphenomandibular ligament. Obliquely downward from the base of the foramen beneath the spine is the mylohyoid groove, behind this groove toward the angle of the mandible is a roughened surface for the attachment of the internal pterygoid muscle.

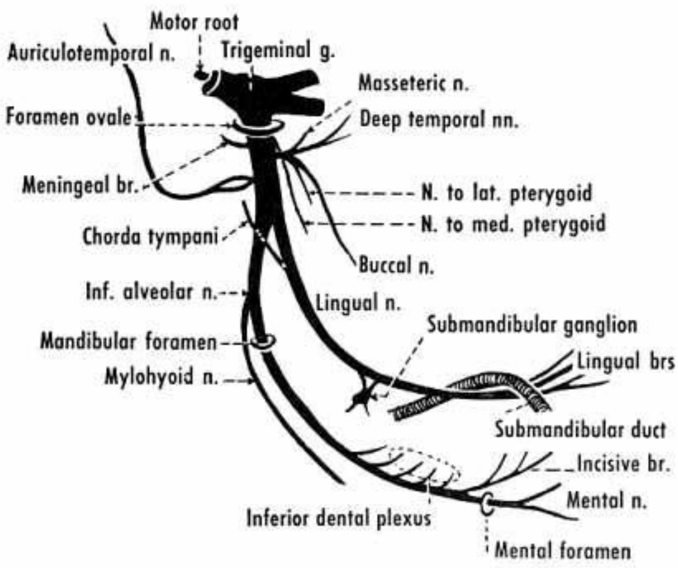
The Inferior Alveolar Artery arises from the Internal maxillary artery medial to the ramus of the mandible, after giving the mylohyoid branch it immediately enters the mandibular foramen and continues downwards and forwards in the mandibular canal, giving off branches to the premolar and molar teeth.

In the vicinity of the mental foramen, it divides into a Mental and an Incisive Branch. In their canals the inferior alveolar and incisive arteries give off dental branches to the individual tooth roots for the supply of the pulp and the periodontal membrane at the root apex.

The Mandibular Nerve leaves the skull through foramen ovale, and almost immediately breaks up into several branches. The chief branch to the lower jaw is the Inferior alveolar nerve. Just before entering the foramen, it releases the Mylohyoid branch, which is primarily a motor branch to the mylohyoid muscle and anterior belly of the digastric muscle.

The Inferior Alveolar Nerve continues forwards through the mandibular canal beneath the roots of the molar teeth to the level of the mental foramen.

The nerve to the teeth does not arise as individual branches but as two or three larger branches which forms a plexus from which Inferior Dental branches enter individual tooth roots and interdental branches supply, alveolar bone, periodontal membrane and gingivae.



At the mental foramen the nerve divides, and a smaller Incisive branch continues forwards to supply the anterior teeth and bone and a larger Mental branch emerges through the foramen to supply the skin of the lower lip and chin.

CLASSFICATION AND ASSESSMENT OF NERVE INJURIES

The face, and in particular the oral and perioral regions, are amongst the areas with the highest density of peripheral receptors, presumably because of their remarkable importance in daily life. It is difficult to tolerate neurological disturbances in the oral and maxillofacial areas compared to disturbances in other parts of the body[72]. Pain, Temperature, Touch, Pressure and Proprioception are transmitted centrally from the perioral structures via the inferior alveolar, lingual, infraorbital and mental nerves[72]. Each of these sensations is carried out by different types of sensory receptors and nerve fibres, each showing different susceptibility to injury and recovery

Maxillofacial neurosensory impairment may complicate various surgical procedures such as third molar extractions, osteotomies, pre prosthetic surgical procedures as well as fracture of facial bones. Additionally, some patients develop neurosensory disturbances unexpectedly following routine surgical procedures

To create a standardized evaluation of the nerve injury[46], to compare injuries between groups of patients, and to relate an injury to a surgical procedure, many classifications were published, but few stood the test of time.

Seddon in 1943[24], proposed a simple and sufficient classification in which nerve damage was divided into 3 subgroups**,** **(Neuropraxia, Axonotmesis, and Neurotmesis)** according to the severity of physical damage to the nerve, compared with the corresponding changes in somatosensory function. Sunderland[46] revised and further subclassified nerve injuries into **Five** grades in 1951. The Seddon and Sunderland classification schemes attempt to correlate histologic changes with clinical outcome.

NEUROLOGICAL TESTS

Patients who sustains an injury presents with a variety of signs and symptoms. As a consequence of nerve injury some patients experience pain conditions and permanent changes in somatosensory function in the midface. Commonly, the somatosensory changes include paresthesia, dysesthesia, and hypo- or hyperesthesia. The recording of postoperative changes in the somatosensory function should include both self-reported measures and quantitative sensory testing of the involved nerve endings

The subjective questionnaire's[8] may be used to assess pain and altered sensation and is a useful tool for monitoring progression of neurosensory recovery. Perhaps the simplest and most reliable measure of subjective patient assessment is the use of a Visual[43] Analog Scale. This is a 10 cm five degree scale, with a degree marked every 2.5 cm. this is a useful tool for monitoring subjective improvement.

If the neurosensory evaluation is based solely on a patient's assessment of symptoms, it is even more difficult to determine whether an expressed complaint of IAN dysfunction is the result of organic nerve damage, psychogenic factors, or even malingering To evaluate nerve dysfunction it is important to use objective testing[40] rather than simply to ask a patient to subjectively report neuropathic changes.

G.E.Ghali and Bruce.N.Epker[16] described a practical approach for evaluating these individuals, which is essential in making intelligent decisions regarding the objective nature of nerve injury, potential for recovery, and/ or possible need for secondary micro neurosurgical intervention. Many refined advanced techniques for testing sensation have been developed for research purposes. But there is also a need from practical point of view to use methods of neurosensory testing that are readily available in clinical practice.

CNT is generally divided into two basic categories,[16]

i) Mechanoceptive and

ii) Nociceptive,

Based upon the specific receptors stimulated through cutaneous contact.

Mechanoceptive testing is further subdivided into

i) Two point discrimination;

ii) Static light touch; and

iii) Brush Directional Stroke.

Nociceptive testing is subdivided into

i) Pin prick and

ii) Thermal discrimination.

It is of significance in regard to receptor specificity that each point on the skin has multiple innervations, with receptor terminals that are specific for only warmth, cold, pain or touch. Therefore during the conduction of clinical neurosensory testing, a rationale sequence for mechanoceptive and nociceptive testing must exist.

In general, mechanoception should be tested before nociception[16,72] to specifically test for those sensory nerve fibres most susceptible to injury by anoxia or excessive pressure.

CONDITIONS FOR NEUROSENSORY TESTING

1) When performing neurosensory testing, all data should be collected by a single investigator, if possible.
2) Patients should undergo testing in the following order,
    i) Two point discrimination
    ii) Static light touch
    iii) Brush directional stroke

iv) Pin prick

v) Thermal discrimination.

vi) Dental vitality

3) A total of four sites[39] should be tested for the mandibular division of the trigeminal nerve. The labiomental fold serves as the horizontal delineation of the upper and lower mental regions.
4) Each specific method of testing should be explained to the patient, with appropriate responses demonstrated.
5) The testing begins after the patient's closes his eyes and separates his lips comfortably. Each of the four facial zones are tested three times; a correct response is considered two out of three appropriate answers.
6) In an attempt to avoid bias during the post-operative tests, patients should not be asked about any subjective loss of sensation; they are asked only to cooperate with the examination.

Sensory testing, probably not only indicates the regenerative capacity of the Inferior alveolar nerve but also collateral sprouting from adjacent intact nerves and central adaptive mechanisms[59]. Therefore the patient's subjective views are important when it comes to evaluating the outcomes of a surgical procedure. Some authors[2,8] have shown that the patient's subjective evaluations give a higher incidence of sensory disturbance than objective[6,43,57] evaluations, while others have reported the opposite.

The objective tests on the average, were slightly sensitive than the subjective test[20]. Clinical neurosensory tests, though more sensitive than subjective tests, were relatively objective. Even in an objective test, it is only the patients who can decide if his or her sensitivity has changed, so, the test is not properly objective.

To overcome this drawback, was developed the advanced testing modalities like, Current Perception Threshold[30], mental nerve Blink Reflex[55], Repeated Nerve Conduction Studies[58], Electrical Stimulation, Electromyography, Vibrotachometry, Somatosensory-Evoked Potentials[15,74], and Thermal Quantitative Sensory Testing.

Despite many refined techniques, there is also a need from practical point of view to use methods of neurosensory testing that are readily available in clinical practice. The usefulness of neurosensory assessment and neurological tests depends on its ability to accurately determine neurosensory deficit and to predict the potential for recovery and the possible future need for further intervention[46].

REVIEW OF LITERATURE

U.K.Akal, N.B.Sayan, S.Aydogan, Z.Yaman, 2000[72] evaluated maxillofacial neurosensory deficiencies caused by various surgical procedures such as tooth extraction, osteotomies, pre prosthetic surgeries, excision of tumors or cysts, surgery of the TMJ and surgical treatment of fractures, and cleft lip and palate. They concluded that osteotomies, *especially BSSO* have the highest incidence of post-operative NSD.

Kari Panula et al, 2001[36] carried out a retrospective study evaluating the incidence of pre, intra and post-operative complications of Orthognathic surgery and their significance to the patient. The study included a total number of 655 patients and despite a reported number of diversity of complications, their frequency seems to be extremely low. The most common complication was a neurosensory deficit in the region innervated by t*he Inferior Alveolar Nerve* and the most severe complication was severe intra-operative bleeding.

Su Gwan Kim et al, **2007**[61] did a retrospective evaluation of the incidence of intra operative and post-operative complications in 301 patients who underwent Orthognathic surgery and their relevance. Despite the great variety of severe complications noted, their frequency seems to be extremely low henceforth stating that orthognathic surgery to be a relatively safe procedure.

Karas et al,1990[67] concluded that 3 months after Lefort I osteotomy, 96% of their patients had full recovery of infraorbital-nerve function. Furthermore, the highest complication rates after LFO were reported in studies concerning pulp vitality.

Al Din et al in 1996[72] reported that Lefort I osteotomy caused alteration of sensation in the maxillary teeth, buccal and palatal mucosa and on the skin of the face. Some of this sensory loss was subtle and may represent an objective alteration in the threshold of sensation rather than subjective numbness or paresthesia

Gunter schultes, Alexander Gaggl,1998[23] evaluated complications following segmental osteotomies. The study reported a high incidence of dental and periodontal trauma in segmental osteotomies following orthognathic surgery.

Torben H Thygesen et al, 2009[67] did a study on intra operative risk factors for long term post -operative complications after Lefort I osteotomy (LFO). The aim of this study was to describe prospectively the overall postoperative changes in maxillary nerve function after LFO, and to correlate these changes with a number of possible intraoperative risk factors. The study concluded that numerous changes in somatosensory functions are to be expected after LFO. In most patients, these changes are minor, and some are dependent on intra operative procedures. Nonetheless, all patients reported satisfaction with surgical results and would recommend the procedure to others.

Zuniga and Essick et al, 1992[43] described a *Testing Algorithm* for grading trigeminal nerve injury based on several clinical sensory tests to determine the level of severity.

NSD FOR MANDIBULAR SURGERY

Karas et al, **1990**[74] reported that in comparison with other surgical procedures such as Lefort I osteotomy, IVRO, or Genioplasty, the SSRO caused the *highest percentage* of post-surgical neurosensory damage assessed by Static Light Touch, Moving Touch Discrimination, and Two Point Discrimination

Mcintosh in 1981[3] published his experience on Neurosensory disturbance (NSD) in relation to SSRO, stating an obvious correlation between age of the patients and the risk of developing nerve dysfunction. He stated that an increase in age has a direct effect on the nerve dysfunction.

Ylikontiola et al, 2000[41]**,** evaluated 30 patients retrospectively, looking specifically at gender, age, magnitude of movement and degree of manipulation of the nerve. They found *statistically significant positive correlation* between subjective neurosensory loss and the patient's age, magnitude of movement, and degree of manipulation of the nerve.

Joseph Van Sickels et al, 2002[35] , did a prospective study analyzing various factors like, age, amount of advancement and effect of concomitant surgeries (Genioplasty) affecting neurosensory recovery following BSSO. Patients were assessed at the site of mental nerve distribution at regular intervals, in 3 age groups, advancement ranges, and additional surgeries. They concluded age at the time of surgery and addition of a genioplasty increases the risk of a neurosensory injury. Larger advancements , further increase the risk of injury in older patients.

S. Nesari, K.-E. Kahnberg, 2005[56] carried out a retrospective study to report the incidence of neurosensory dysfunction in the lower lip and chin after bilateral sagittal split osteotomy at four Post-operative time points, and the relation of impairment to factors connected with the operation. Sixty-eight patients who had undergone the procedure (at 136 operated sites) were reviewed, and neurosensory recovery was studied at 2, 6, 18 and finally 30 months postoperatively .This retrospective study shows that the most important factors influencing postoperative nerve function are patient age, fixation method and the perioperative position of the inferior alveolar nerve.

Fiamminghi and Aversa in 1979[72] performed a cadaver based study and suggested that the greatest risk of nerve disruption occurred at the time of the surgical split. **Brusati et al in 1981** shared that opinion and to minimize that risk, proposed the use of a fine spatula to achieve a precise sagittal cleavage.

Tamas et al in 1987[52] examined the course of the mandibular canal with frontal radiographs of a dry skull and observed a bone marrow space between the mandibular canal and the external cortical bone, the absence of which is considered as a risk factor for canal injury during sagittal split ramus osteotomy, was not observed in 20% of the cases. He also suggested that CT scans are useful for observing the bone marrow space, **Teerijoki-Oksa et al**,***2002*** reported that low corpus height and the location of the mandibular canal near the inferior border of the mandible may increase the risk of injury to the inferior alveolar nerve.

Jones and Wolford, 1990[5] using intraoperative recording of somatosensory evoked potentials indicated that the initial retraction of the bundle medial to the ramus during the preparation of the osteotomy cuts was the only consistent factor related to neuropraxia. The subsequent split and bicortical screw fixation did not appear to be related to altered nerve conduction. According to some authors **(Jones et al in 1990[5])** the vascular supply may also be compromised if the nerve is exposed during surgical procedures.

Takeuchi et al, 1994[72,60] reported that in SSRO setback patients, the distance between the mental foramen and the mandibular ramus always decreased and that this change may cause trigeminal nerve hypoesthesia by compression of the nerve trunk because of posterior shifting of the proximal segments.

Fridrich et al,1995[42] also stated that as long the inferior alveolar nerve was intact, the long term chance (at least 6 months) for neurosensory recovery was good, despite manipulation.

Nishioka et al, (1987); Lindquist and Obeid ,(1988); Scheerlink et al, (1994); Acebal-Bianco,(2000)[35] noted a higher incidence of neurosensory injuries when a BSSO is combined with a genioplasty than when a genioplasty is performed alone.

Aldo Bruno Gianni et al 2002[5] analyzed the effect of concomitant Genioplasty with sagittal osteotomy in fifty European populations, concluding the same as other authors. The combination of genioplasty and sagittal split osteotomy seems to be more detrimental for the lip sensibility than genioplasty or sagittal split osteotomy alone.

Anwad Al Bishri et al, 2004[8] assessed NSD in 84 patients who underwent concomitant genioplasty (37 patients). On the contrary, he concluded that differences in the incidence of sensory disturbance after sagittal split osteotomy for mandibular advancement and setback were not significant. The combination with genioplasty *did not increase* the incidence of sensory disturbance. Sensory changes after the osteotomies do not serve to be the main determinant of the patient's satisfaction.

Pratt et al, 1996[35] reported that miniplate osteosynthesis after SSO was followed by better function of the inferior alveolar nerve than intermaxillary fixation in combination with upper border wiring.

Fujioka et al, 1998[28] reported higher incidence of NSD following lag screw fixation and monocortical osteosynthesis caused less damage to the IAN than bicortical osteosynthesis.

J.Hu et al 2007[27] did an experimental study in monkeys assessing the function of the IAN in SSRO following monocortical and bicortical fixation on opposing sides of each mandible. Their results suggest that the nerve damage during SSRO could be temporary and reversible, and monocortical fixation may result in restoration of the nerve function *sooner* than bicortical fixation.

Lemke et al, **2000**[74] reported that rigid fixation resulted in more anesthesia in the mental nerve distribution than wire fixation when tested with a brush stroke direction.

J.P.Richard van Merkestyn et al, 2007[28] assessed the incidence of permanent NSD of the inferior alveolar nerve after bilateral sagittal split osteotomy and possible influence of the technique used. The study concluded that the use of sagittal split separators without the use of chisel may play an important role in the relatively low percentage of persistent hypoesthesia of the IAN.

Akiko Kobayashi et al, **2006**[4] investigated NSD in patients after Orthognathic surgery comparing the two techniques namely, (BSSO and Inverted ramus osteotomy) used to correct mandibular deformity, in relation to differences in mandibular splitting methods and degree of surgical skill. The study concluded that post surgical neurosensory disturbances of the lower lip and chin occur more frequently in SSRO patients treated by surgeons having little experience than in those treated by skilled surgeons although the difference is not significant.

Robeto becelli et al, 2002[54]**,** assessed NSD in a group of 60 patients who underwent BSSO pre-surgically and post-surgically. In his study, he observed that the highest rate of recovery of the IAN functionality was observed at the sixth month. This finding witnesses, Neuropraxia and axonotmesis give a spontaneous recovery that most frequently occurs within 6 months from surgery, independent of age and sex of the patient. The persistence of anesthesia over a 12 month period could be a sign of neurotmesis. **Jones et al**, observed perfect sensory improvement 6 months postsurgery, evaluated by TSEP.

Kirk.L.Fridrich, Timothy.J.Holton, Kim.J.Pansegran, Michael.J.Buckley,1995[57] conducted a prospective study evaluating the neurosensory recovery pattern of the IAN following BSSO by means of objective and subjective means , reporting that long term chance for neurosensory recovery is good, despite intraoperative nerve manipulation. Patients seem to adapt and report normal neurosensory function even though objective neurosensory testing indicates continued neurosensory deficit.

S.K.Jaaskelainen, J.K.Peltola, R.Lehtinen, in 1996[55] evaluated the diagnostic value of new modification of the Blink Reflex with the stimulation of the distribution of the mental nerve in iatrogenic lesions in the IAN. The results of the mental nerve blink reflex test and the CNT were closely related. Irrespective of the possible co existent sensory signs and symptoms, a normal mental nerve blink reflex within two months after the operation also predicted a reasonably good recovery at one year.

Giuseppe Colella et al, **2007**[20] did a systematic review of the incidence of IAN sensory disturbance after BSSO, as well as the frequency of recovery of sensory function using objective methods of evaluation. On the basis of the results they concluded, objective methods provide the most sensitive diagnostic tests at early controls, i.e, within three months of the operation. At later control points the sensitivity increases and the inter- rater reliability is satisfactory.

SEGMENTAL OSTEOTOMIES AND NEUROSENSORY DEFICITS

Poswillo DE in 1972[47] carried out an experimental study on two monkeys with open bite treated by maxillary segmental surgery .At 2, 3, 4 and 6 months postoperatively a tooth was removed from the repositioned segment by segmental excision of an enclosing block of alveolus and examined microscopically. The early microscopic examination of the teeth in the repositioned segment showed fibrosis of the pulp and loss of nerves and the odontoblast layer. At 6 months, the teeth had viable pulps without sensory nerves.

Robinson PP in 1986[47] on the contrary demonstrated that mandibular canines are reinnervated by regenerating inferior alveolar nerve fibres despite repositioning of the segments and insertion of a bone graft at the osteotomy site. **Holland GR, Robinson PP in 1986**[18] again using cats as a model, confirmed that reinnervation of the teeth occurred, but the reinnervated myelinated axons were fewer in number, smaller in size and had thinner myelin sheaths. The nonmyelinated fibres had fewer axons per fibre.

Zisser and Gattinger,1977[23] reported on pulp perfusion deficiency in patients treated by total osteotomy below the apices of the teeth

Rudzki-Janson, 1994[23] confirmed a high incidence of root and nerve damage with difficult segmental osteotomies in spite of new osteotomy techniques.

Gunter schultes, Alexander Gaggl,1998[23] evaluated complications following segmental osteotomies. The study reported a high incidence of dental and periodontal trauma in segmental osteotomies following orthognathic surgery.

Johnson and Hinds in 1969[47] pointed out that an adequate blood supply is essential for vitality. **Leibold DG, Tilson HB, Rask KR, in 1971** found the maxillary canines to be more frequently non responsive after segmental osteotomy, attributing this to the high position of the apices which made them vulnerable to periapical surgical trauma. On the contrary **Tajima in 1975** studied response to electric pulp testing in 27 cases of Lefort I osteotomy and reported that sensation recovered quicker and more completely in canines than molars, premolars, and incisors.

Dejongh M, Barnard D, Birnie D[47] compared electric and thermal pulp testing of 10 patients after Lefort I osteotomy with 10 matched controls, however it was difficult to draw any conclusions between the two small groups. **Kahnberg and Engstorm**[47] followed 30 patients who underwent Lefort I osteotomy for 18 months and found that response was lost immediately post operatively in almost all the patients, with returning to 90% in almost all the patients.

De Jongh et al in 1986[47] reported that, although there was a statistically significant reduction in response of both dental tissues and soft tissues in the maxilla following Lefort I osteotomy, recovery of sensory function was random and should be expected considering the severed nerve fibers during the surgical procedures.

Bell et al in 1988[47] carried out a histologic examination of 17 maxillary third molars that had maxillary Lefort I osteotomy, with a mean follow up for 40 months. They found that the teeth had normal pulpal architecture with an intact odontoblastic layer. There was no evidence of pulpal necrosis and peripheral plexus of nerve bundles were seen clearly, in most of the sections.

Kiyoshi Harada, 2004[38] assessed blood flow and neurosensory changes in the maxillary pulp after different Lefort I osteotomy using laser Doppler flowmetry and concluded that the method of maxillary osteotomy influences the post-operative changes of the pulpal blood flow and recovery of the pulpal sensitivity in the maxillary teeth.

Tamar. Justus, Benjamin.L.Chang, Dale Bloomquist and Douglas.S.Ramsay,**in 2001**[64] studied using laser Doppler flowmetry to investigate the effects of Lefort I osteotomy on maxillary pulpal and gingival blood flow between the first and third week after surgery. It provided evidence that pulpal blood flow is increased between first and third week after Lefort I osteotomy but it did not find a significant change in the gingival blood flow. Long term assessments have reported significant reduction in pulpal blood flow, below presurgical baseline measurements.

Torben H Thygesen et al, 2009[67] assessed sensory nerve action potentials (SNAP's) which is used as a diagnostic test for traumatic neuropathic trigeminal disorders, to the maxillary nerve. They suggest that SNAP's of the maxillary nerve can be a valuable technique for a comprehensive examination of the trigeminal system.

MATERIALS AND METHODS

Six patients who reported to the Department of Oral and Maxillofacial Surgery, Tamil Nadu Government Dental College, Chennai, in need of Dentofacial deformity correction were included in this study. Patients requiring orthognathic surgery consisting of Anterior maxillary osteotomy, Bilateral Sagittal split osteotomy, Anterior mandibular osteotomy and Genioplasty were enrolled in our prospective study.

Ethical approval was obtained for the study from the Institutional Ethical Committee and informed consent obtained from each patient in regional language (Tamil), explaining the nature of the surgical procedure and the study.

The patients were 3 males and 3 females and their ages ranged from 20-29 years of age. Patients were examined clinically, model and radiographic analysis done, treatment options explained. The Pre-surgical assessment revealed that patients were healthy and neurological disease free, exhibited no sensory disturbances in the IAN & ION region. To analyze the correlation of the variables with the nerve recovery pattern, data regarding direction and amount of repositioning, the surgical technique, and postsurgical infections were recorded for each case

The patients were examined for nerve functionality, by an array of tests. Pre-surgically and Post surgically (at intervals of 1 week, 1 month, 3 months and 6 months respectively.)

Objective testing included Light touch using cotton wisps, Two-point discrimination using Vernier caliper (calibrated in mm), Tactile discrimination using camel brush , Thermal stimuli, and vitality testing of teeth by vitality scanner. Subjective tests included subjective questionnaire (in local language) and visual analog scale, with aid from the examiner for assisting the patients understanding but in no way influencing the patient's responses.

SUBJECTIVE QUESTIONNAIRE

1.Have you experienced any sensory disturbance after the operation in;

i) Upper lip ii) Lower lip iii) Chin

iv) Tongue v) Cheek vi) Teeth

2. In which side is your sensation altered?

i) Right ii) Left iii) Both

3. If you have / had any sensory disturbance, when did this begin?

i) Immediately after the operation

ii) sometimes after the operation

Comments ___________________________

4. Would you describe the sensory disturbance as;

i) Anaesthesia ii) Pinching iii) Tickling

iv) Painful v) Burning vi) Others

Comments ______________________________

5. Does the changed sensation cause any problem for you?

i) Always ii) At touching iii) When chewing

iv) When Talking v) When Eating vi) Others

6. Has the sensory changes made you bite yourself by mistake in the

i) Lip ii) Cheek iii) Tongue

7. Has the sensory changes made you burn yourself in the the lip or tongue?

i) Yes ii) No

Comments _______________________________

8. How would you describe the discomfort you experienced as a consequence of the altered sensation? Indicate with an (x) on the line below

0________________________5_________________________10

(No discomfort) (Intolerable Discomfort)

9. For how long have you had the altered sensation?

i) Less than a month ii) Two months iii) Four months

iv) Six months

10. On which side is your sensation still altered?

i) Right ii) Left iii) Both

11) Are you satisfied with the result of the operation?

i) Yes ii) No

Comments____

12) With your experience would you recommend this kind of treatment to others ?

i) Yes ii) No

Comments____

SUBJECTIVE QUESTIONNAIRE

In the questionnaires proposed to the patients, a question is asked to quantify the discomfort due to the sensorial deficit on a VAS ranging from 0 to 10, representing the discomfort with 0 when “absent” and with 10 when “intolerable.” The values obtained were gathered in 5 categories[6]:

- 0-2: absent or mild
- 2-4: mild to moderate
- 4-6: moderate
- 6-8: moderate to serious
- 8-10: serious

TWO POINT DISCRIMINATION

Static two point test examines the slowly adapting A α fibres. Two point discrimination thresholds a minimum separation between two points, for which a subject discriminates two points from one point of contact. A Vernier caliper, calibrated (in mm) is used. The test was conducted by beginning with the points closed and progressively opening them in 1 mm increments until the patient could discriminate two points. This distance was then recorded. Care was taken to ensure that the points touched the cutaneous surface at the same time; distances 2mm greater than the pre-operative value were considered abnormal.

LIGHT TOUCH

This test examines the myelinated A α fibres and would reflect large axonal neuropathy.This test is performed by gently stroking the patient’s skin using a cotton wisp. The response is recorded as Postive or Negative

BRUSH DIRECTIONAL STROKE

This test selectively discriminates for large myelinated quickly adapting, Aα sensory nerve fibres. This test is done using a camel hair brush. It is applied in a I cm stroke three times in each zone. The examiner randomly decides whether he/she will move the stroke from above/ below to below/ above in each interval. An accurate response is considered as an accurate indication of the direction the monofilament is travelling in at least two out of three applications.

PIN PRICK

This test examines the small myelinated Aδ and C fibres which convey pain stimuli. The device used in testing pin prick is a 22 or 23[16] gauge needle held between the thumb and index finger. It is applied firmly in a quick pricking fashion. A sufficient intensity of application should draw a small drop of blood at the puncture site. This may be repeated up to three times; the first correct response means no further pricking is necessary. An appropriate response should be feeling sharp, not dull intense pain. We recorded only positive or negative responses.

TEETH VITALITY TESTING

The sensation of the maxillary and mandibular teeth[39] was measured at each above specified interval, and the sensation on each side was estimated to be normal if all the teeth on the side reacted positively to the test, if one tooth did not react positively to the sensory test the result was recorded as abnormal. Teeth that had failed to respond to the test preoperatively were excluded.

	1 week	1 month	3 months	6 months
2-POINT WEBERTEST				
STATIC LIGHT TOUCH				
BRUSH DIRECTIONAL				
PIN PRICK				
QUESTIONNAIRE				

CASE RECORD

Name : Date of birth : Date :

Postal address : Age : O.P.No :

Sex :

Father's name/Guardian's name :

Occupation :

HISTORY

Presenting complaints

Sibling Male Female

Consanguineous / Non- consanguineous

Parent's General and Dental conditions

Siblings General and Dental conditions

Familial diseases

Type of home care

Diet: Vegetarian/Non – Vegetarian

History of orthodontic treatment

Parent's Concern for Orthodontic Treatment

PRE-NATAL HISTORY

Informer

Delivery

Type

Drugs taken during pregnancy

POST NATAL HISTORY

Feeding Breast / Bottle combination

Duration and frequency

Milestones of development

Childhood diseases Rickets/Diphtheria/Scarlet fever/

Epilepsy/Mumps/Measles/Adenoids/Tonsillitis/Allergy

4.HABITS:

None

Finger/Thumb sucking Which Digit:

Age stopped:

Duration:

Intensity

Frequency

Others Tongue biting / Tongue thrusting

H/O Tonsillectomy or Adenoidectomy

5. INJURIES

6. FAMILIAL MALOCCLUSION HISTORY:

Parents(Type of malocclusion) Similar / Dissimilar

Siblings (Type of malocclusion) Similar / Dissimilar

PHYSICAL EXAMINATION RECORD

1.PHYSICAL STATUS:

Built Ectomorphic / Mesomorphic / Endomorphic

Height Weight Gait

Posture	Body type
Present health	Good / Fair / Poor

EXTRA ORAL EXAMINATION

Shape of the head:	Dolichocepalic/Mesocephalic/Brachycephalic
Facial Form	Mesoprosopic/Leptoprosopic/Euryprosopic
Facial divergence	Straight/Anterior/Posterior
Inter labial gap	
Lip Posture and Tonicity	
Upper lip	Short / Long / Normal
Lower lip	Short / Long / Normal
Relationship	Competent / Incompetent
Mentolabial sulcus	Normal / Shallow / Deep
Nasolabial angle	Obtuse / Acute / Right angle
Clinical FMA	Average / High / Low
Chin	Retruded / Normal / Protruded

3.FUNCTIONAL EXAMINATION

Respiration	Nasal / Oral / Oro nasal
Deglutition	Normal /Abnormal
Speech	Normal / Abnormal
Path of closure	Normal / Deviated
TMJ symptoms	
Postural rest position	
Peri oral Muscle activity	Normal / Hyperactive / Hypotonic
Amount of Incisor Exposure	During speech
	During smile

Others

4. INTRA ORAL EXAMINATION

SOFT TISSUE

Oral hygiene status	Good/ satisfactory/ poor
Gingival Texture	Normal/ Edematous/ Poor
Frenal Attachment	Upper- Normal/ Abnormal
	Lower- Normal/ Abnormal
Tongue	Size
	Posture
	Movements
Oral Mucosa	Normal/ Abnormal
Palatal contour	Normal/ Shallow/ Deep

HARD TISSUE

No. of Permanent Teeth

No. of Deciduous teeth

Teeth Present

Unerupted teeth

Supernumerary/ Missing Teeth

Shape, Size, Form of Teeth	Normal/ Abnormal
Texture	Normal/ Hypoplastic

Caries

Endodontically Treated

Occlusal Wear

Key Ridge Position

INTRA ARCH EXAMINATION

Shape	Average / V shaped/ U shaped/ Square
Arch symmetry	Symmetrical/ Asymmetrical

Arch alignment

Crowding

Spacing

Rotation

Axial Inclination

Other Individual Irregularities

INTER ARCH EXAMINATION

a ANTEROPOSTERIOR EXAMINATION

First Molar Relation	Right
	Left
Canine Relation	Right
	Left
Overjet (mm)	
Cross bite	

b. VERTICAL RELATIONSHIPS

Overbite	Normal
	Deep Bite
	Open bite
	Closed bite

c. TRANSVERSE RELATIONSHIP

Bite	Cross bite / Open bite / scissors bite

Midline Upper

Lower

Together

CURVE OF SPEE :

PHOTOGRAPHS

CEPALOMETRIC ANALYSIS

OPG INTERPRETATION

1. Teeth present
2. Teeth absent
3. Root Formation
4. Root Resorption
5. Eruption levels
6. Lamina dura and height of interdental crest
7. Supernumerary teeth
8. Third molar status
9. Pathological conditions
10. Any others

SPECIAL INVESTIGATIONS

DIAGNOSIS:

PROBLEM LIST

TREATMENT OPTIONS

TREATMENT PLAN

SURGICAL PROCEDURE

All the six patients involved in the study, underwent Orthognathic surgery and additional esthetic procedures. The surgeries performed were, Bilateral Sagittal Split Osteotomy, Anterior Segmental Osteotomy, Lower Subapical Osteotomy, and Genioplasty.

All the patients were evaluated presurgically (by means of all routine investigations), and were found to be fit to undergo the procedure. All the procedures were done under general anesthesia via nasal intubation and infiltration with 2 % lidocaine with 1;1,00,000 epinephrine into the surgical sites.

BILATERAL SAGITTAL SPLIT OSTEOTOMY (BSSO):

To visualize the mandibular bone, reflection and retraction of the periosteum was accomplished following mucovestibular incision, by means of curved retractors. The bone cuts were excavated on the medial aspect of the ramus just few millimeters above the entrance of the IAN into the mandibular canal, on the lateral aspect of the ramus few millimeters anteriorly to the mandibular angle, and on the crestal cortical bone connecting the two aforementioned osteotomies. All the bone cuts were obtained with medium and short burs. The splitting procedures were performed using a hammer and fine chisels first, then with a Smith's separator. After the splitting procedure was completed, the integrity and the position of the IAN were assessed in all patients by visual check. After mobilization of the distal fragment, maxillomandibular fixation was performed and the correct occlusion was set using the fabricated surgical splint, and were fixed with monocortical screws and wound closure done with resorbable sutures.

ANTERIOR MAXILLARY OSTEOTOMY:

A vestibular incision was carried out from canine to canine in the upper jaw. After subperiosteal dissection, the anterior maxilla up to the piriform aperture was exposed. After extraction of the first premolars, a palatal mucoperiosteal flap elevated in relation to canine and premolar. A vertical osteotomy line was performed running through the alveolar socket of the extracted premolar on the both sides. To respect the teeth apices in the anterior maxillary sinus wall and inferior to the piriform aperture during the horizontal osteotomy line, a series of marks 5 mm above their contours was made using a fissure bur. Based on these marks, a horizontal osteotomy was carried out between the apex of the anterior teeth and the piriform aperture connecting the vertical osteotomies of the right and left sides. After its mobilization, the anterior dentoalveolar bone block was trimmed using a vulcanite bur and thereafter repositioned on a prefabricated occlusal splint. After rigid fixation with miniplates, the wound closure was performed with restorable material.

GENIOPLASTY:

A mucoperiosteal flap was reflected through an incision in the labial vestibule from left to right canine and tunnels were created to allow for adequate exposure and identification of the mental nerves. A bow-shaped osteotomy was made with a fissure bur at the lower border of the mandible from the area between the second premolar and the first molar on one side to the same area on the opposite side. The final separation of bone was completed with an osteotomy. The osteotomized bony segment was mobilized and placed in the desired position. Fixation was by rigid fixation, followed by closure.

LOWER ANTERIOR SUBAPICAL OSTEOTOMY:

A mucoperiosteal flap was reflected through an incision in the labial vestibule from left to right canine and tunnels were created to allow for adequate exposure and identification of the mental nerves. The mental nerves were protected and premolars were extracted and horizontal osteotomy cuts were made, 5mm below the apices of the mandibular anterior teeth. A vertical osteotomy line was performed running through the alveolar socket of the extracted premolar on the both sides. Care is taken not to perforate the lingual flap. The segment is then mobilized and fractured. The segment is placed in the desired position by means of the fabricated pre surgical surgical splint, followed by rigid fixation of the segments. Wound was closed in layers by resorbable sutures.

CASE REPORT – 1

Name	: Mr. Kadar meeran	O.P.No : 117532
Postal address :	C-34, 1st block, New washermanpet, Chennai.	Age : 28 yrs
		Sex : Male

HISTORY

Presenting complaints: Forwardly placed lower anterior teeth and lower jaw.

Parent's general and Dental conditions: Normal

Siblings General and Dental conditions: Normal

HABITS: None

H/O Tonsillectomy or Adenoidectomy: Nil

FAMILIAL MALOCCLUSION HISTORY:

Parents(Type of malocclusion) Dissimilar

Siblings (Type of malocclusion) Dissimilar

PHYSICAL EXAMINATION RECORD

1.PHYSICAL STATUS:

Built	: Mesomorphic	Height	: 168 cms
Weight	: 66 kgs	Gait	: Normal
Posture	: erect	Present health	: well-built and apparently healthy

EXTRA ORAL EXAMINATION

Shape of the head:	Mesocephalic
Facial Form	Mesoprosopic
Facial divergence	Anterior
Inter labial gap	0 mm
Upper lip	Normal and hypotonic
Lower lip	Normal
Relationship	Competent
Mentolabial sulcus	Shallow
Nasolabial angle	Acute
Clinical FMA	Low
Chin	Normal
Perioral Muscle activity	Hyperactive

Amount of Incisor Exposure During speech 1 mm
During smile 3 mm

INTER ARCH EXAMINATION

a ANTEROPOSTERIOR EXAMINATION

First Molar Relation Right: Class III
Left : Class III

Canine Relation Right: Class III
Left : Class III

Overjet (mm) Reverse- 6mm

b. VERTICAL RELATIONSHIPS

Overbite edge to edge

c. TRANSVERSE RELATIONSHIP

Midline Upper coinciding with midline
Lower coinciding with midline
Together 3 mm deviation towards the left

DIAGNOSIS: This is a case of class III malocclusion with an orthognathic maxilla and prognathic mandible with horizontal growth pattern.

PROBLEM LIST: i) Orthognathic maxilla
ii) Prognathic mandible
iii) Reverse over jet
iv) Class III molar and canine relation

TREATMENT PLAN: BSSO.

CASE REPORT – II

Name : Mr. Krishnan O.P.No : 41202

Postal address: #18, Valluvar nagar, Chennai. Age : 21

Sex : Male

HISTORY

Presenting complaints : C/o forwardly placed upper & lower front teeth.

Parent's general and Dental conditions : Normal

Siblings General and Dental conditions: Normal

HABITS: Nail biting since childhood, does it occasionally.

H/O Tonsillectomy or Adenoidectomy: Nil

FAMILIAL MALOCCLUSION HISTORY:

Parents(Type of malocclusion) : Dissimilar

Siblings (Type of malocclusion) : Dissimilar

PHYSICAL EXAMINATION RECORD

PHYSICAL STATUS:

Built : Ectomorphic Height : 150 cms

Weight : 54 Kgs Gait : Erect

Posture : Normal Present health : apparently healthy

EXTRA ORAL EXAMINATION

Shape of the head: : Mesocephalic

Facial Form : Leptoprosopic

Facial divergence : Straight

Inter labial gap : 6 mm

Upper lip : Short hypotonic and protruded

Lower lip : Normal and Normotonic

Relationship : Incompetent

Mentolabial sulcus : Deep

Nasolabial angle : Acute

Clinical FMA : Average

Chin : Normal

Perioral Muscle activity : Hyperactive

Amount of Incisor Exposure During speech 5 mm

During smile 9 mm

INTER ARCH EXAMINATION

a ANTEROPOSTERIOR EXAMINATION

First Molar Relation Right : Class I

Left : Class I

Canine Relation Right : Class I

Left : Class I

Overjet (mm) Normal

b. VERTICAL RELATIONSHIPS

Overbite Normal- 2 mm

c. TRANSVERSE RELATIONSHIP

Midline Upper Coincides with facial midline

Lower coincides with facial midline

Together coincides with each other

DIAGNOSIS: This is a case of angle class I Dento alveolar malocclusion on a class I skeletal base attributed to prognathic maxilla and prognathic mandible, associated with average growth pattern normal over bite and over jet.

PROBLEM LIST: Prognathic maxilla and mandible

Proclination of upper and lower incisors

Decreased naso labial angle

Protruded lips

TREATMENT PLAN: Anterior maxillary osteotomy.

Lower sub apical osteotomy.

CASE REPORT – III

Name : Miss. R. Sangeetha O.P.No :116573

Postal address : Middle street, kizh villivakkam, vandhavasi, Thiruvannamalai.

Age : 28 yrs. Sex : Female

HISTORY

Presenting complaints: forwardly placed upper anterior teeth during rest and smiling.

Parent's general and Dental conditions: Mother had similar complaints.

Siblings General and Dental conditions: Nil

Parent's Concern for Orthodontic Treatment: Motivated

H/O Tonsillectomy or Adenoidectomy: Nil

FAMILIAL MALOCCLUSION HISTORY:

Parents(Type of malocclusion) : Similar

PHYSICAL EXAMINATION RECORD

1.PHYSICAL STATUS:

Built : Endomorphic Height : 155cms

Weight: 50 Gait: Normal

Present health : Moderately built apparently healthy

EXTRA ORAL EXAMINATION

Shape of the head : Mesocephalic

Facial Form : Mesoprosopic

Facial divergence : Posterior

Inter labial gap : 7 mm

Upper lip : Short and hypotonic

Lower lip : Short

Relationship : Incompetent

Mentolabial sulcus : Deep

Nasolabial angle : Acute

Clinical FMA : High

Chin : Retruded

Amount of Incisor Exposure — During speech: 8 mm

During smile : 10 mm

INTER ARCH EXAMINATION

a ANTEROPOSTERIOR EXAMINATION

First Molar Relation	Right: class II
	Left : class II
Canine Relation	Right : class II
	Left : class II
Overjet (mm)	12 mm
Cross bite	Nil

b. VERTICAL RELATIONSHIPS

Deep Bite: 4-5 mm

c. TRANSVERSE RELATIONSHIP

Midline	Upper: Normal
	Lower: Mild shift to the right
	Together: Not coinciding

DIAGNOSIS: This is the case of angle class II div I malocclusion on a class II skeletal pattern with prognathic maxilla and increased mandibular plane angle.

PROBLEM LIST: Convex profile
Proclination of anterior
Crowding in lower anteriors
Class II molar & canine relationship
Short upper lip with incompetence.

TREATMENT PLAN: Anterior maxillary osteotomy.

CASE REPORT - IV

Name	: Miss. Sathayakala	O.P.No	: 73245
Postal address	: Mariamman kovil street, Pondicherry.	Age	: 28
		Sex	: Female

HISTORY

Presenting complaint: Forwardly placed upper anterior teeth.

Parent's general and Dental conditions: Normal

Siblings General and Dental conditions: Normal

HABITS: None

H/O Tonsillectomy or Adenoidectomy: Nil

FAMILIAL MALOCCLUSION HISTORY:

Parents(Type of malocclusion) Dissimilar

Siblings (Type of malocclusion) Dissimilar

PHYSICAL EXAMINATION RECORD

PHYSICAL STATUS:

Built	: Ectomorphic	Height	: 157 cms
Weight	: 51 kgs	Gait	: normal
Posture	: errect	Present health	: Moderately built apparently healthy

EXTRA ORAL EXAMINATION

Shape of the head:	Dolichocepalic
Facial Form	Leptoprosopic
Facial divergence	Anterior
Inter labial gap	7 mm
Upper lip	Short and hypertonic
Lower lip	Short
Relationship	Incompetent
Mentolabial sulcus	Deep
Nasolabial angle	Acute
Clinical FMA	Average
Chin	Retruded
Peri oral Muscle activity	Hyperactive

Amount of Incisor Exposure During speech 7 mm
During smile 9 mm

INTER ARCH EXAMINATION

a ANTEROPOSTERIOR EXAMINATION

First Molar Relation Right : Class II
Left : Class II

Canine Relation Right : Class II
Left : Class II

Overjet (mm) 8 mm

b. VERTICAL RELATIONSHIPS

Deep Bite : 4-5 mm

c. TRANSVERSE RELATIONSHIP

Midline Upper coinciding with the facial midline
Lower coinciding with the facial midline
Together deviation towards the right side

DIAGNOSIS: This is a case of class II malocclusion on a class II skeletal base with prognathic maxilla and retrognathic mandible.

PROBLEM LIST: Proclined upper anteriors
Class II molar and canine relation

TREATMENT PLAN : Anterior maxillary osteotomy and lower sub apical osteotomy.

CASE REPORT – V

Name : Mr. Siddiq O.P.No : 117251

Postal address : 34, Royce road, Pudupet, Chennai. Age : 20 yrs

Sex : Male

HISTORY

Presenting complaints: Forwardly placed lower front teeth.

Parent's general and Dental conditions: Normal

Siblings General and Dental conditions: Normal

HABITS:

Thumb sucking till 13 yrs of age

H/O Tonsillectomy or Adenoidectomy: NIl

FAMILIAL MALOCCLUSION HISTORY:

Parents(Type of malocclusion) Dissimilar

Siblings (Type of malocclusion) Dissimilar

PHYSICAL EXAMINATION RECORD

PHYSICAL STATUS:

Built	: Mesomorphic	Height	: 170 cms
Weight	: 68 kgs	Gait	: Normal
Posture	: erect	Present health	: Well- built apparently healthy

EXTRA ORAL EXAMINATION

Shape of the head:	Brachycephalic
Facial Form	Leptoprosopic
Facial divergence	Anterior
Inter labial gap	0 mm
Upper lip	Short hyperactive
Lower lip	Normal
Relationship	Competent
Mentolabial sulcus	Shallow
Nasolabial angle	Acute
Clinical FMA	Low
Chin	Normal

Peri oral Muscle activity Hyperactive

Amount of Incisor Exposure During speech 2 mm

During smile 5 mm

INTER ARCH EXAMINATION

a ANTEROPOSTERIOR EXAMINATION

First Molar Relation Right : Class III

Left : Class III

Canine Relation Right: Class III

Left : Class III

Overjet (mm) Reverse 10 mm

Cross bite in the Anterior region

b. VERTICAL RELATIONSHIPS

Open bite 2.5 mm

c. TRANSVERSE RELATIONSHIP

Midline Upper coinciding with the midline

Lower coinciding with the midline

Together coinciding with each other

DIAGNOSIS: This is a case of angles class III malocclusion on a class III skeletal base with a retrognathic maxilla and prognathic mandible with average growth pattern.

PROBLEM LIST: Retrognathic maxilla

Prognathic mandible

Anterior open bite

Class III molar and canine relation

Reverse over jet

TREATMENT PLAN: Le Fort I osteotomy and bi lateral sagittal split osteotomy.

CASE REPORT - VI

Name: Karuppiah O.P.No : 111216

Postal address : 116, veerasami st, manali, Chennai. Age : 26 yrs

Sex : Male

HISTORY

Presenting complaints Difficulty in breathing during sleep, loud snoring, day time sleepiness

H/O Tonsillectomy or Adenoidectomy Nil

PHYSICAL EXAMINATION RECORD

1.PHYSICAL STATUS:

Built : Mesomorphic Height : 168 cms

Weight : 64 kgs Gait : Normal

Posture : erect Present health : moderately built apparently healthy

EXTRA ORAL EXAMINATION

Shape of the head:	Mesocephalic
Facial Form	Euryprosopic
Facial divergence	Posterior
Inter labial gap	0
Upper lip	Normal
Lower lip	Normal
Relationship	Competent
Mentolabial sulcus	Shallow
Nasolabial angle	Normal
Clinical FMA	High
Chin	Retruded

3.FUNCTIONAL EXAMINATION

Respiration	oronasal
Deglutition	Normal
Speech	Normal
Path of closure	Normal

TMJ symptoms Nil

Peri oral Muscle activity Normal

INTER ARCH EXAMINATION

a ANTEROPOSTERIOR EXAMINATION

First Molar Relation Right Class I
Left Class I

Canine Relation Right Class I
Left Class I

Overjet (mm) 2 mm

b. VERTICAL RELATIONSHIPS

Overbite 2 mm

c. TRANSVERSE RELATIONSHIP

Midline: Upper and Lower coinciding with the facial midline

DIAGNOSIS: Obstructive sleep apnea.

TREATMENT PLAN: Genial advancement

OBSERVATION AND RESULTS

The six patients operated for the correction of Dentofacial deformity were closely observed for neurosensory and somatosensory function and recovery, pre operatively and post operatively at intervals of 1 week, 1 month, 3 months and 6 months following surgery.

The patients were observed for

i) Neurosensory and somatosensory recovery and assessment (By means of subjective and objective testing)

ii) Occlusion, stability and relapse.

iii) Infection

Prior to surgery, no patient had impaired function of the inferior alveolar nerve or infraorbital nerve in the any of the zones in the lower lip, chin and upper lip region. Pertaining to BSSO, in relation to the study, during BSSO out of the four sides, nerve was identified in three sides and one required manipulation of the nerve to position in the distal segment.

Two point discrimination;

Amongst all the testing methods used to evaluate neurosensory status, the 2– PD was the most meaningful[14].

All the six patients felt reduced sensation following 2-PD post surgically immediately one week after surgery. The relation of the mandibular canal to the lateral cortex of the mandibular ramus can affect the incidence of nerve damage One patient who underwent BSSO (needed nerve manipulation to position the nerve in the distal segment) reported reduced sensation even 3 months post surgery with values greater than 14mm. All the other patients reported near normal sensation I month post surgery. Both the patients had setback of 7mm, but had relatively fewer NSD in the assessment period. Patients who underwent segmental osteotomies returned to near normal sensation in the infraorbital region and chin within their normal range. At the end of 6 months all the patients reported near normal sensation subjectively though objective testing revealed mild deficits in the cutaneous sensation.

Light touch.

Five out of the six patients reported light touch perception using cotton wisps, one week post surgery. One patient was unable to perceive the light touch in the chin area immediately post surgery and 1 month following BSSO. But all the patients recovered and perceived normal sensation at 1 month, 3 months and 6 months respectively.

Brush directional stroke

All six patients perceived the direction of the brush stroke, and this was observed equally in all the patients. Patients were able to point out the direction of the stroke done randomly following surgery at the prescribed intervals of neurosensory testing.

Pin prick sensation

Five out of the six patients perceived pin prick sensation and one patient reported dull sensation following BSSO in the chin area at I week and I month following surgery. All patients reported normal sensation following 3 months and at the 6 month post operative follow ups.

Dental vitality testing

Dental vitality testing revealed that segmental osteotomies had higher influence on the vitality. Patients reported “reduced” or “no response” following anterior segmental and subapical osteotomies. The anterior’s had no response immediately following surgery, when compared with their counterparts (posterior teeth). The incisors had a slower recovery in the 3month period with “delayed response” while canines still had no response. The canines with their closer proximity to the osteotomy cuts showed decreased or prolonged response in the assessment using analytic pulp tester. The canines as stated in the literature had a prolonged recovery period in this study. The mandibular teeth (vitality testing for BSSO) also recovered slower than the cutaneous sensation on the face.

Almost most of the patients, reported normal sensation(subjectively) after 6 months following surgery, though objective testing revealed some mild deficits on comparison with the pre-operative levels.

Occlusion and stability was assessed in all the patients and all the patients had a good occlusion with reasonable stability and no relapse. One of the patients had a hardware exposure following surgery(BSSO) and was operated for its removal.

The results show that, as Westermark et al pointed out, the surgeon should thoroughly explain the postoperative numbness to the patient before surgery. This step is very important, because numbness decreases the overall satisfaction with the surgery.

The small number of samples and the heterogeneity of the methods used for testing sensory changes were the other notable limitations of this study. Finally, a detailed 12-24 month follow up of patients could provide useful information concerning the time necessary for recovery of the various forms of sensitivity.

DISCUSSION

Mandibular osteotomies are generally followed by predictable and stable results, but one of their few drawbacks is lower and upper lip hypoesthesia[3]. Most instances of neurosensory deficit are reversible, but permanent changes may also occur.

Using objective tests as detection means, the percentage of lesion- affected nerves after mandibular osteotomy ranges between 9% and 85.5%, and using subjective tests, it ranges between 9% and 100. *Coghlan and Irvine*[53], demonstrated normal sensation subjectively in 74% of patients with SSO but objective testing demonstrated normal sensation in only 34%.

The purpose[20] of sensory diagnostic evaluation is to document whether or not a neurosensory disturbance exists, to quantify the disturbance, to monitor sensory recovery, to determine whether or not microreconstructive surgery may be indicated, and to monitor sensory recovery following microreconstructive surgery.

The evaluation of neurosensory disturbance along the distribution of the inferior alveolar nerve (chin and lower lip) can be performed by either purely subjective or relatively objective methods. The methods used to assess sensory loss vary. Most studies of sensory disturbances after mandibular osteotomies are based on either objective or subjective methods.

The preoperative level of sensory perception also seems to be a major determinant of the relative changes occurring after mandibular osteotomy.

To evaluate nerve function accurately it is important to use testing procedures rather than simply asking a patient to subjectively to report neuropathic changes The Clinical Neurosensory Testing algorithm is good to "*rule in*" IAN injuries and therefore should be considered a clinically useful test, however it is less reliable in "*ruling out*" IAN injury and may result in high incidence "false negative" findings.

CNT, though objective in nature, it is only the patients who can decide if his or her sensitivity has changed, so, the test is not properly objective. Some studies have shown that the patient's subjective evaluation give a higher incidence of sensory disturbance than objective evaluations, while others have reported the opposite.[8]

No matter which objective tests is used to identify sensory defect, assessment of inter-examiner reliability is important, as the ability of the objective test to discriminate between impaired and unimpaired sensation may vary depending on the examiner. SEP[68], Mental nerve Blink reflex[55], Thermographic assessment, seems to be more sensitive method for judging NSD.

From a clinical viewpoint however the objectivity and sensitivity of advanced testing must be weighed against the expense of the equipment and expertise required for doing the recording. LT, BTD, TPD and PIN may be less sensitive than SEP, but nevertheless provide practical, inexpensive, easily applied methods of evaluating NSD. The objective tests were, on the average, slightly more sensitive than the subjective tests. .

Studies indicates that changes in threshold measures of sensory function during the first 6 months post surgically cannot be understood fully in the absence of patients' subjective reports of altered sensations. In this study the subjective questionnaire was also incorporated to provide a comparison with objective data to assess neurosensory recovery from patient's vantage. Patients seem to adapt and report normal neurosensory function even though objective testing indicated continue NSD.

In this study, a combination of both subjective and objective testing has been applied to evaluate the NSD for the patients. By studying the relationship between altered sensation and sensory impairment longitudinally for 1–2 years, it may be possible to better predict during the first few postoperative months which patients are likely to have favourable or unfavourable sensory recoveries.

Studies done on neurosensory assessment generally recommend 1 year[55,35] to verify resolution of a neurosensory alteration, because it has been shown that patients may report sensory disturbances in the immediate post-operative period, the majority experience almost total recovery within 12 months post-operatively (Hohl and Epker, 1976; Nishioka et al., 1987). However studies by *Fridrich et al* and also by (Becelli[53], Karas and Jones et al) shows that patients performed significantly poorer on all the neurosensory tests at one week and one month post operatively, however by 6 months (Becelli,Karas and Jones et al) the test values reached a normal level where no statistically significant differences existed when compared with preoperative values for both right and left sides. Henceforth the patients in this study were assessed at intervals of 1 week, 1 month, 3 months and 6 months.

The induction of neural impairment is thought to be influenced by multiple causal factors[35], including patient age, fixation methods[49], postoperative swelling, and surgical procedures, magnitude of mandibular movement[35]. In addition to the operative technique the individual anatomic course of the IAN[52] is also an important factor in the occurrence of NSD.

Damage to the IAN, may be *Direct* or *Indirect*. Indirect damage of the IAN may result from post-operative edema. It has been postulated that IAN *is most vulnerable* during the actual splitting process.. Although the nerves dissected from the lateral fragments had a greater degree of NSD during follow up. They ultimately recovered to the same level as the nerves not encountered or visible but embedded in the medial fragment. Correspondingly in our study out of the four sides, the IAN was exposed in in three out of the four sides, while one required manipulation to position it in the distal segment. Though initially the patient reported reduced sensation in the two point discrimination and static light touch, recovery was equally good as compared to the other three sides.

As mentioned in the literature, sensory impairment following genioplasty[19] was minimal in the study, but recovered with time and not affecting the patient's daily activities.

Sensibility testing of teeth by vitality scanner[39] has not been used routinely before to evaluate the neurosensory disturbance after sagittal split osteotomy. The vitality results correspond to normalize more slowly than the sensation of skin in the same area.

Studies on sensory nerve supply of the maxilla after osteotomy, relate to segmental procedures and these studies have focused on the vitality of the teeth. Few studies concerning somatosensory problems related to LFO have been published, and only a few authors have described these potential side effects in depth. Some studies conclude that the side effects of LFO are minor[67] and transient. It is generally associated with only minor postoperative complications.

Among these complications, the most frequent are dysesthesia and paresthesia in the area innervated by the infraorbital nerve and in the facial and palatal gingival in the upper jaw. The most persistent complication after LFO seems to be decreased sensory function in the upper teeth[67] The magnitude of the dissection and the positioning of retractors would appear to be conceivable causes for postoperative sensory disturbances of the ION. In agreement to Rosenberg and Sailer[60] patients experienced almost near normal cutaneous sensation following segmental osteotomy in the study period of 6 months.

The most persistent[64] complication after LFO seems to be decreased sensory function in the upper teeth. Furthermore, the highest complication rates after LFO were reported in studies concerning pulp vitality. Vedtofte observed pulp canal obliteration in 2.3% as a side effect, with a risk of pulp necrosis, and increased incidence of long term pathologic changes even many years after surgery.

During Le Fort I osteotomy and segmental osteotomies, the Nasopalatine nerve; the Anterior, Middle Superior alveolar nerves, Posterior superior alveolar nerves, and the small terminal nerves in the buccal mucosa along the incision lines between the upper first molars are always divided, yet it is surprising that these patients do not more frequently complain of numbness after surgery which divides so many branches[47].

Studies tell us that Le Fort osteotomies are a safe[61] and efficient procedure for the correction of maxillary deformities and the incidence of complications can be lowered to acceptable levels through the exercise of careful surgical techniques[30]. In the case of the IAN, the neurosensory alterations after the orthognathic surgery was larger and sensory recovery took slightly longer[72] than the ION. This indicates that mandibular surgeries are more aggressive in nature, resulting in more nerve damage. The operator must exercise additional care when conducting mandibular surgical procedures

SUMMARY & CONCLUSION

Neurosensory disturbance is the most common complication of orthognathic surgery that lowers the satisfaction level of the patient. All maxillofacial surgeons should have a minimum of understanding of the diagnosis and management of nerve injuries according to the so called legal parameters.

For legal reasons, it is necessary to mention typical complications during preoperative counseling. Not only should the patient be informed of the frequency of complications, but they should also be told its implications in later life.

The patient has to be informed in a most suitable and detailed way about the risks of the surgical procedure before obtaining the informed consent. Surgeons should thoroughly explain the postoperative numbness to the patient before surgery. This step is very important because numbness decreases the overall satisfaction with the surgery.

Spontaneous sensory recovery occurs, in most, but not all patients. The deficit observed is not serious, and the reduced nerve function does not radically alter the quality of life because the sensitivity of the inferior lip and chin regions appears slightly inferior, but does not affect the patient’s daily activities.

This consideration is well documented by the capacity of the central nervous system to compensate for the peripheral conduction deficits due to nervous lesions. Some sensorial alterations, identifiable through electrophysiologic examination or specific tests of sensitivity, can be insufficient to interfere with the patient's daily activities and can also be barely detectable. Thanks to these adaptive mechanisms, clinically detectable deficits are often always compensated for or hidden by modifications at a central level and do not influence the patients' quality of life, which remains the most important variable to consider in case of elective interventions, such as orthognathic surgery.

Careful planning with treatment simulation, model surgery and additional care during surgery minimizes complications considerably. To conclude, *Orthognathic Surgery is relatively a safe procedure*, despite the reported variety of complications.

BIBLIOGRAPHY

1. **A. J. Bennett, D. G. Wastell, G. R Barker, C. W. Blackburn, J. P. Rood**; Trigeminal somatosensory evoked potentials: A review of the literature as applicable to oral dysesthesias; Int. J. Oral Maxillofac Surg. 1987;16:408-415.
2. **A. Westermark, H. Bystedt, L. Von Konow**; Inferior alveolar nerve function after sagittal split osteotomy of the mandible: correlation with degree of intraoperative nerve encounter and other variables in 496 operations; British journal of Oral Maxillofacial surgery 1998;36:429-433.
3. **A. Westermark, H. Bystedt, L. Von Konow**; Inferior alveolar nerve function after mandibular osteotomies; British Journal of Oral and Maxillofacial Surgery 1998;36:425-428.
4. **Akiko Kobayashi, HidemiYoshimasu, Jyunji Kobayashi**, **TeruoAmagasa**; Neurosensory Alteration in the Lower Lip and Chin Area After Orthognathic Surgery: Bilateral Sagittal Split Osteotomy Versus Inverted L Ramus Osteotomy; J Oral Maxillofac Surg 2006;64:778-784.
5. **Aldo Bruno Gianni, OrnellaD'Orto, Federico Bibligoli, Alberto Bozzeti, Roberto Brusati**; Neurosensory alterations of the inferior alveolar and mental nerve after genioplasty alone or associated with sagittal osteotomy of the mandibular ramus; Journal of Cranio-Maxillofacial Surgery 2002;30:295-303.
6. **Antonio D'Agostino, Lorenzo Trevisol, Fabio Gugole, Vincenzo Bondi, Pier FrancessoNocini**; Compilcations of Orthognathic surgery;the IAN; J CraniofacSurg 2010;21: 1189-1195.

7. **Ashraf F. Ayoub, Zahidlalani, Kursheed F. Moos, Graham A.Wood**; Complications following orthognathic surgery that required early surgical intervention: Fifteen years' experience; Int J Adult Orthod Orthognath Surg. 2001;16:138-144.
8. **Awwad Al-Bishri, Gunnar Dahlberg, ZiadBarghash, Jan Rosenquist, Bo Sunzel**; Incidence of neurosensory disturbance after sagittal osteotomy alone or combined with genioplasty; British Journal of Oral and Maxillofacial Surgery 2004;42:105-111.
9. **Awwad. Al-Bishri, Jan Rosenquist, Bo Sunzel**; On Neurosensory Disturbance After Sagittal Split Osteotomy; J Oral Maxillofac Surg 2004;62:1472-1476.
10. **Awwad. Al-Bishri, Z. Barghash, J. Rosenquist, B. Sunzel**; Neurosensory disturbance after sagittal split and intraoral vertical ramus osteotomy: as reported in questionnaires and patients' records; Int. J. Oral Maxillofac. Surg. 2005;34:247-251.
11. **Barton M. Gratt, Vivek Shetty, Maryam Saiar, Edward A. Sickles**; Electronic thermography for the assessment of inferior alveolar nerve deficit; Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;80:153-60.
12. **Ceib Phillips, Se Hee Kim, Greg Essick, Myron Tucker, Timothy A**. **Turvey**; Sensory retraining after orthognathic surgery: Effect on patient report of altered sensations; J Orthod Dentofacial Orthop 2009;136:788-94.
13. **Charles Feng;** Looking Good; the psychology and Biology of beauty.
14. **Christof Urs Joss, Urs Walter Thues**; Neurosensory and functional impairment in sagittal split osteotomies: a longitudinal and long-term follow up study; European Journal of Orthodontics 2007;29:263-271.

15. **Claudio Arcuri, Fabiana Muzzi, Rafaella Docimo, Elio Fusco, Flavia Pauri, Paola Maria Rossini**; Somatosensory Evoked Potentials of inferior Alveolar Nerve; J Oral Maxillofac Surg 2006;64:594-599.

16. **G. E. Ghali, Bruce N. Epker**; Clinical Neurosensory testing: Practical Applications; J Oral Maxillofac. Surg. 1989;47:1074-1078.

17. **G.** K**. Essick, C. Phillips, T. A. Turvey, M. Tucker**; Facial altered sensations and sensory impairment after orthognathic surgery; Int. J. Oral and Maxillofac. Surg. 2007;36:577-583.

18. **G. R. Holland, P. P. Robinson**; Reinnervation of teeth after segmental osteotomy; Int. J Oral Maxillofac. Surg. 1986;15:437-443.

19. **Gary J. Nishioka, Mark Mason, Joseph E. Van Sickels**; Neurosensory Disturbances Associated with the Anterior Mandibular Horizontal Osteotomy; Int. J Oral Maxillofac. Surg. 1988;46:107-110.

20. **Giuseppe Colella, Rosangela Cannavale, Antonio Vicidomini, Antonio Lanza**; Neurosensory Disturbance of the Inferior Alveolar Nerve After Bilateral Sagittal Split Osteotomy: A Systematic Review; J Oral Maxillofac Surg 2007;65:1707-1715.

21. **Giuseppe Colella, Rosangelacannavale, Antonia Vicidomini, Antonio Lanza**; Neurosensory Disturbance of the inferior Alveolar Nerve After Bilateral sagittal Split Osteotomy: A Systematic Review; J Oral MaxillofacSurg 2007;65:1707-1715.

22. **Graham I. Smith, Peter A. Brennan, SeongSeob Oh, Anthony F. Markus;** Modification of the Hunsuck sagittal split osteotomy using a nerve book. Technical note; Journal of Cranio-Maxillofacial Surgery 2002;30:292-294.

23. **Gunter Schultes, Alexander Gaggl**; Periodontal Disease Associated With Interdental Osteotomies After Orthognathic Surgery; J. Oral Maxillofac Surg 1998;56:414-417.

24. **H. J. Seddon**; A Classification of Nerve Injuries; British Medical Journal 1942.

25. **Helen C. Travess, Susan J. Cunningham, Jonathon T. Newton**; Recovery of sensation after orthognathic treatment: Patients' perspective; J Orthod Dentofacial Orthop 2008;134:251-9.

26. **J. G. Wijbenga, C. R. A. Verlinden, J. Jansma, A. G. Becking, B. Stegenga:** Long-lasting neurosensory disturbance following advancement of the retrognathic mandible: distraction osteogenesis versus bilateral sagittal split osteotomy; Int. J. Oral Maxillofac. Surg. 2009;38:719-725.

27. **J. Hu, Q. Zhao, J. Tang, Z. Zheng, M. C.** Qi; Changes in the inferior alveolar nerve following sagittal split ramus osteotomy in monkeys: A comparison of monocortical and bicorticalfixcation; British Journal of Oral and Maxillofacial Surgery 2007;45:265-271.

28. **J. P. Richard van MERKESTEYN, Albert ZWEERS, Johan E.M. CORPUTTY**; Neurosensory disturbances one year after bilateral sagittal split mandibular ramus osteotomy performed with separators; Journal of Cranio-Maxillofacial Surgery 2007;35:222-226.

29. **Janneane F. Gent, David M. Shafer, Marion E. Frank**; The Effect of Orthognathic Surgery on Taste Function on the Palate and Tongue; J Oral MaxillofacSurg 2003;61:766-733.

30. **JiWoon Park, Pill-HoonChoung, Hong SeopKho, Young Ku Kim, Jin Woo Chung**; A comparison of neurosensory alteration and recovery pattern among different types of orthognathic surgeries using the current perception threshold; Oral Surg Oral Med Oral Pathol Oral Endod 2010 (articles in press).
31. **Johan P. Reyneke , Peter Tsakiris, Piet Becker**; Age as a Factor in the Complication Rate After Removal of Unerupted/Impacted Third Molars at the Time of Mandibular Sagittal Split Osteotomy; J Oral Maxillofac Surg2002;60:654-659.
32. **John R. Zuniga, Roger A. Meyer, John M. Gregg, Michael Miloro, Leon F. Davis**; The Accuracy of Clinical Neurosensory Testing for Nerve Injury Diagnosis; J Oral Maxillofac. Surg. 1998;56:2-8.
33. **John R. Zuniga**; Trigeminal Ganglion Cell Response to Mental Nerve Transection and Repair in the Rat; J Oral Maxillofac. Surg. 1999;57:427-437.
34. **John R.de Almeida, Ashlin J. Alexander, Mark G. Shrime, Ralph W. Gilbert, David P. Goldstein;** Otolaryngology-Head and Neck Surgery: Development and preliminary validation of the Lip Reanimation Outcomes Questionnaire; 2010;143:361-366.
35. **Joseph E. Van Sickels, John P. Hatch, Calogero Dolce, Robert A. Bays, John D. Rugh**; Effects of Age, Amount of Advancement, and Genioplasty on Neurosensory Disturbance after a Bilateral Sagittal Split Osteotomy; J Oral MaxillofacSurg 2002;60:1012-1017.
36. **Kari Panula, KajFinne, KyostiOikarinen**; Incidence of Complications and Problems Related to Orthognathic Surgery: A Review of 655 Patients; J Oral MaxillofacSurg 2001, 59:1128-1136.

37. **Kirk L. Fridrich, Rimothy J. Holton, Kim J. Pansegrau, Michael J. Buckley**; Neurosensory Recovery Following the Mandibular Bilateral Sagittal Split Osteotomy; J Oral Maxillofac. Surg. 1995;53:1300-1306.
38. **Kiyoshi Harada, Masaru Sato, Ken Omura**; Blood-flow and neurosensory changes in the maxillary dental pulp after differing Le Fort I Osteotomies; Oral And Maxillofacial Surgery; Oral Pathology; Oral Medicine; Oral surgery; 2004;97:12-17.
39. **L. Ylikontiola, J. Kinnunen, K. Oikarinen**: Comparison of different tests assessing neurosensory disturbances after bilateral sagittal split osteotomy; Int. J Oral Maxillofac. Surg. 1998;27:417-421.
40. **LeenaYlikontiola, JanneVesala, KyostiOikarinen**; Repeatability of 5 clinical neurosensory tests used in orthognathic surgery; Int J Adult Orthod Orthognath Surg. 2001;16:36-46
41. **LeenaYlikontiola, Jormakinnunen, KyostiOikarinen**; Factors Affecting Neurosensory Disturbance After Mandibular Bilateral Sagittal Split Osteotomy; J Oral MaxillofacSurg 2000;58:1234-1239.
42. **Lisa Yip, Peter Korczak**; Clinical audit on the incidence of inferior alveolar nerve dysfunction following mandibular sagittal split osteotomies at the Derby Royal Infirmary, England; Int J Adult OrthodOrthognath Surg. 2001;16:266-271
43. **Lucas J. Poort, Johan W. van Neck, Karel G.H van Wal**; Sensory Testing of Inferior Alveolar Nerve Injuries: A Review of Methods Used in Prospective Studies; J Oral MaxillofacSurg 2009;67:292-300.
44. **Marci H. Levine**; Inferior Alveolar Nerve Canal Position: A Clinical and Radiographic Study.

45. **Meredith August, Jose Marchena, JanaeDonady, Kaban**; Neurosensory Deficit and Functional Impairment After Sagittal ramus Osteotomy: A Long-Term Follow-Up Study; J Oral MaxillofacSurg 1998;56:1231-1235.

46. **Michael Miloro**; Contemporary Oral and Maxillofacial Surgery; Volume 2:819-837.

47. **O. F. Shehab Al din, K.M. Coghlan, P. Magennis**; Sensory nerve disturbance following Le Fort I osteotomy; Int. J Oral Maxillofac. Surg. 1996;25:13-19.

48. **P. A. Heasman, A. D. G. Beynon**; Clinical considerations from axon-myelin relationship in human inferior alveolar nerve; Int. J Oral Maxillofac. Surg. 1987;16:346-351.

49. **Paul J.W. Stoelinga, Wilfred A. Borstlap**; The Fixations of Sagittal Split Osteotomies With Miniplates: The Versatility of a Technique; J Oral MaxillofacSurg 2003;61:1471-1476.

50. **Pushkar Mebra, Vanessa Castro, Rogerio Z**. **Frettas, Larry M. Wolford**; Complication of the Mandibular Sagittal Split Ramus Osteotomy Associated With the presence or absence of the Third Molars; J Oral Maxillofac Surg 2001;59:854-858.

51. **Rainer B. Dommer**; The History of the “Le Fort I Osteotomy”;J Oral Maxillofac.Surg. 1986;14:119-122.

52. **Reiko Yamamoto, Atsusbinakamura, KobsukeObno, Ken-icbMicbi**; Relationship of the Mandibular Canal to the Lateral Cortex of the Mandibular Ramus as a factor in the Development of Neurosensory Disturbance After Bilateral Sagittal Split Osteotomy; J Oral Maxillofac. Surg. 2002;60:490-495.

53. **Robert L. Campbell, Ronald G. Shamskin, Stephen W. Harkind, Richmond Va**; Assessment of recovery from injury to inferior alveolar and mental nerves; Oral Surg Oral Med Oral Pathol 1987;64:519-26.

54. **Roberto Becelli, GiancarioRenzi, Andrea Carboni, GiulioCerulli, GiulioGasparini;** Inferior Alveolar Nerve Impairment After Mandibular Sagittal Split Osteotomy: An Analysis of Spontaneous Recovery Patterns Observed in 60 Patients; J. Craniofac. Surg. 2002;13:315-320.

55. **S. K. Jaaskelainen, J. K. Peltola, R. Lehtinen**; The mental nerve blink reflex in the diagnosis of lesions of the inferior alveolar nerve following orthognathic surgery of the mandible; British journal of Oral Maxillofacial surgery 1996;34,87-95.

56. **S**. **Nesari, K. E. Kahnberg, L. Rasmusson**; Neurosensory function of the inferior alveolar nerve after bilateral sagittal ramus osteotomy: a retrospective study of 68 patients; Int. J Oral Maxillofac. Surg. 2005;34:495-498.

57. **S**.**Hillerup**; latrogenic injury to the inferior alveolar nerve: etiology, signs and symptoms, and observations on recovery; Int. J. Oral Maxillofac. Surg. 2008;37:704-709.

58. **Satu K. Jaaskelainen, Juha K. Peltola, Kai Forssel, KimmoVahatalo**; Evaluating Function of the Inferior Alveolar Nerve Repeated Nerve Conduction Tests During Mandibular Sagittal Split Osteotomy; J Oral Maxillofac Surg 1995;53:269-279.

59. **Stefan Bothur, John Eric Blomqvist**; Patient Perception of Neurosensory Deficit after Sagittal Split Osteotomy in the Mandible; Plast. Reconstr. Surg. 1998;102: 325.

60. **Stefan Schultze-Mosgau, HolgerKrems, Rudolf, Friedrich WilbelmNeukam**; A Prospective Electromyographic and Computer-Aided Thermal Sensitivity Assessment of Nerve Lesions After Sagittal Split Osteotomy and Le Fort I Osteotomy; J Oral MaxillofacSurg 2001;59:128-139.
61. **Su-Gwan Kim, Sun-Sik Park**; Incidence of Complications and Problems Related to Orthognathic Surgery; J Oral MaxillofacSurg 2007;65:2432-2444.
62. **T. Renton, A. Thexton, M. Hankins, M. McGruk**; Quantitative thermosensory testing of the lingual and inferior alveolar nerves in health and after iatrogenic injury; British Journal of Oral and Maxillofacial Surgery 2003;41:36-42.
63. **T**. **Teerijoki-Oksa, S. K. Jaaskelainen, K. Forssell, H. Forssell**; Recovery of nerve injury after mandibular sagittal split osteotomy. Diagnostic value of clinical and electrophysiologic tests in the follow-up; Int. J. Oral Maxillofac. Surg. 2004;33:134-140.
64. **Tamara Justus, Benjamin L. Chang, dale Bloomquist, Douglas S. Ramsay**; Human Gingival and Pulpal Blood Flow During Healing After Le Fort I Osteotomy; J Oral Maxillofac. Surg. 2001;59:2-7.
65. **Thomas Scholz, Gregory R. D. Evans**; Peripheral Nerve Anatomy for Regeneration Studies in Pigs: Feasibility of Large Animal Models; Ann Plast Surg 2010;65:43-47.
66. **Thomas Teltzrow, Franz-Josef Kramer, Andrea Schulze, Carola Baethge, Peter Brachvogel**; Perioperative complications following sagittal split osteotomy of the mandible; European Association for Cranio-Maxillofacial Surgery 2005;33:307-313.

67. **Torben H. Thygesen, Allan bardow, Sven Erik Norbolt, John Jensen, Peter Svensson, DrOdont**; .Surgical Risk Factors and Maxillary Nerve Function After Le Fort I Osteotomy; J Oral MaxillofacSurg 2009;67:528-536.
68. **Torben H. Thygesen, Allan bardow, Sven Erik Norbolt, John Jensen, Peter Svensson, DrOdont**; Risk Factors Affecting Somatosensory Function After Sagittal Split Osteotomy; J Oral MazillofacSurg 2008;66:469-474.
69. **Torben H. Thygsen, Lene Baad-Hansen, Peter Svensson, DrOdont**; Sensory Action Potentials of the Maxillary Nerve: A Methodologic Study With Clinical Implications; J Oral Maxillofac Surg 2009;67:537-542.
70. **Trevor Veltkamp, Peter H. Buschang, Jeryl D, Jarnes Bates, Sterling R. Schow**; Predicting lower lip and chin response to mandibular advancement and genioplasty; J Orthod Dentofacial Orthop 2002;122:627-34.
71. T**suneo Yoshida, Takeshi Nagamine, TadaharuKobayshi, Noboru Michimi, Tamio Nakajima, Hitoshi sasakura, Koji hanada**; Impairment of the Inferior Alveolar Nerve after sagittal Split Oesteotomy; J. Cranio-Maxillofac. Surg. 1989;17:271-278.
72. **U. K. Akal, N. B. Sayan, S. Aydogan, Z. yaman**; Evaluation of the neurosensory deficiencies of oral and maxillofacial region following surgery; Int. J Oral Maxillofac. Surg. 2000;331-336.
73. **Wheeler's**; Dental Anatomy Physiology and Occlusion; 6th Edition.

74. **Yukari Hashiba, Koichiro Ueki, KoheiMarukawa, Mayumi Shimada, Kan Yoshida, Chika Shimizu, ShamiulAlam, Kiyomasa Nakagawa, Kanazawa**; A comparison of lower lip hypoethesia measured by trigeminal somatosensory-evoked potential between different types of mandibular osteotomies and fixation; Oral Surg Oral Med Oral Path Oral Radiology and Endo 2007;104:177-85.
75. **Zhong Xing Wu, Li Wu Zheng, Zu Bing-Li, San Jie Ye Weng, Xue Wen Yang, Yao Dong, Roger A. Zwahlen**; Subapical Anterior Maxillary Segmental Osteotomy: A Modified Surgical Approach to Treat Maxillary Protrusion; J Craniofac Surg 2010;21:97-100.

ABBREVIATIONS

IAN -	Inferior Alveolar Nerve
ION -	Infraorbital Nerve
BSSO -	Bilateral Sagittal Split Osteotomy
LT -	Light Touch
TPD -	Two Point Discrimination
NSD -	Neurosensory Deficit
LFO -	Lefort Osteotomy
PIN -	Nociception
SEP -	Somatosensory Evoked Potential

Frontal view

Pre-operative

Post-operative

Profile view

Pre-operative

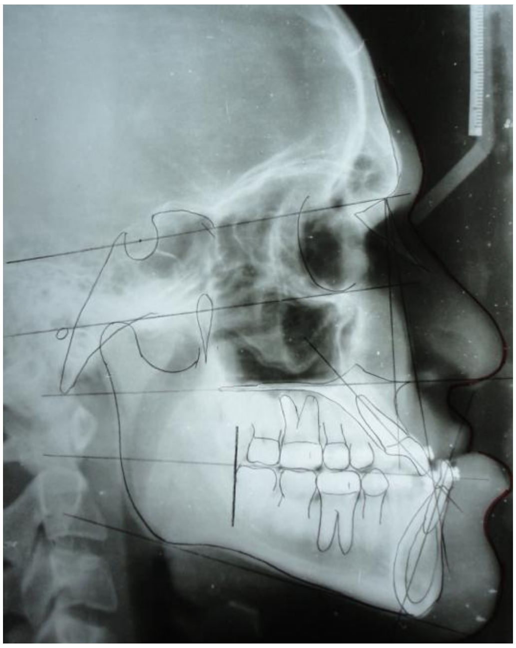
Post-operative

Three Quarter view

Pre-operative

Post-operative

Pre-operative



Post-operative

Frontal view

Pre-operative

Post-operative

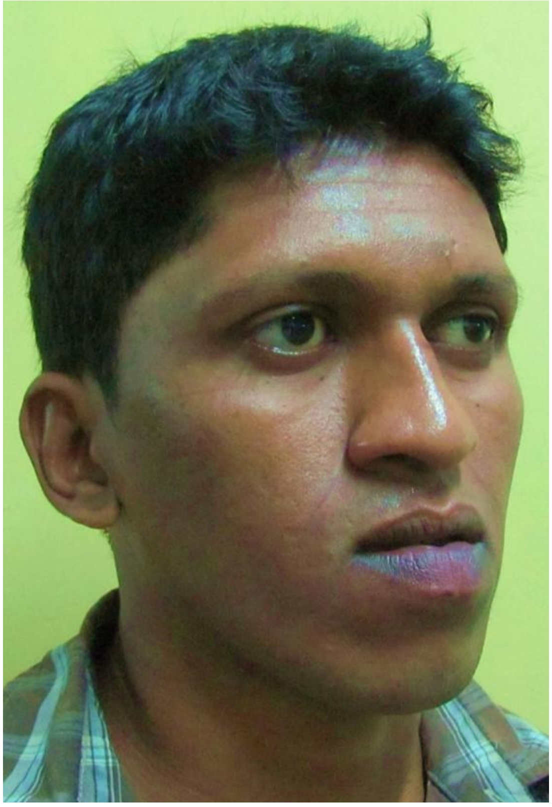
Profile view

Pre-operative

Post-operative

Three Quarter view

Pre-operative



Post-operative

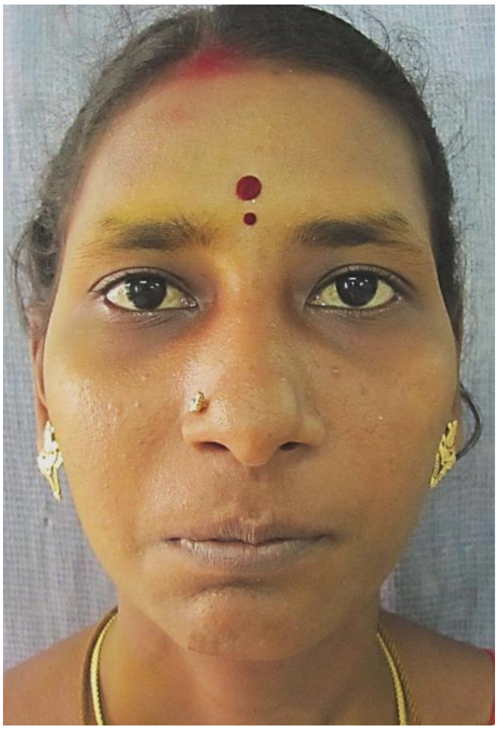
Pre-operative

Post-operative

Frontal view

Pre-operative

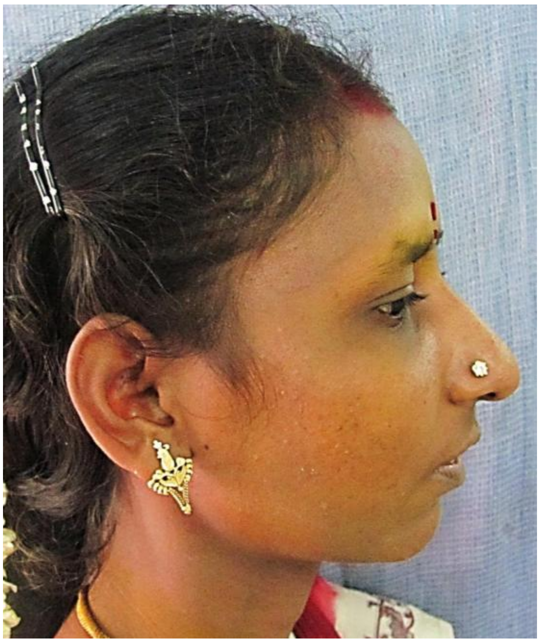
Post-operative



Profile view

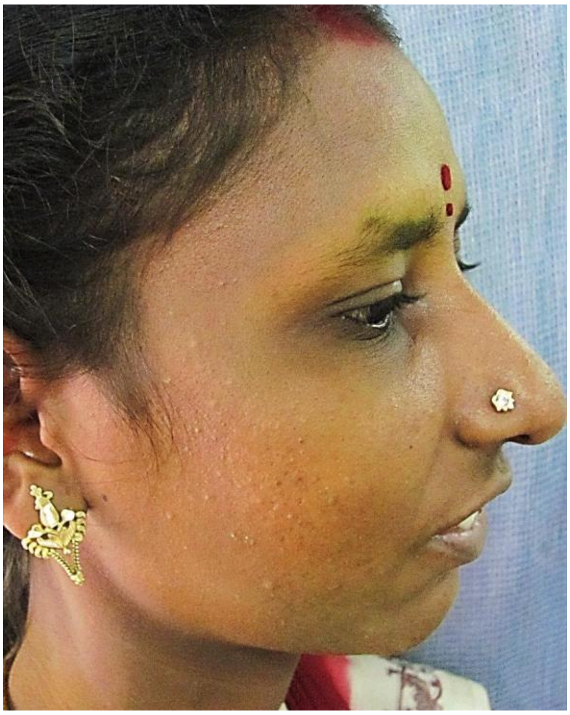
Pre-operative

Post-operative



Three Quarter view

Pre-operative	Post-operative



Pre-operative	Post-operative

Frontal view

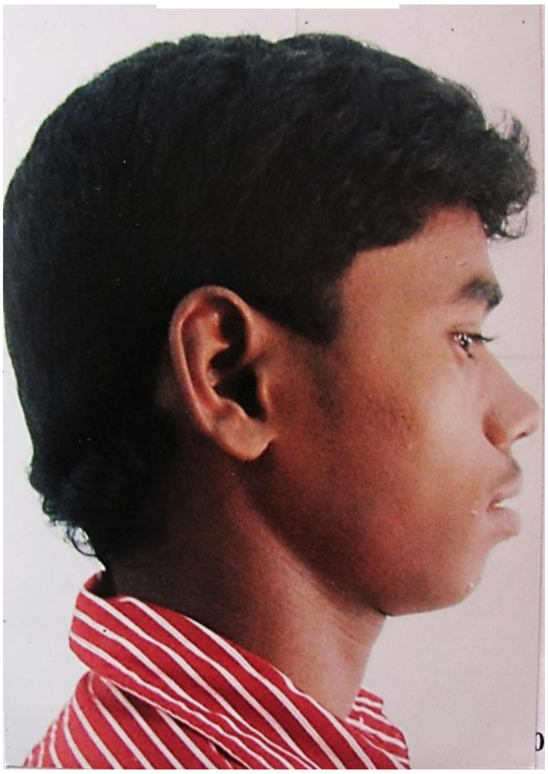
Pre-operative

Post-operative

Profile view

Pre-operative

Post-operative



Three Quarter view

Pre-operative

Post-operative

Pre-operative

Post-operative

Frontal view

Pre-operative

Post-operative

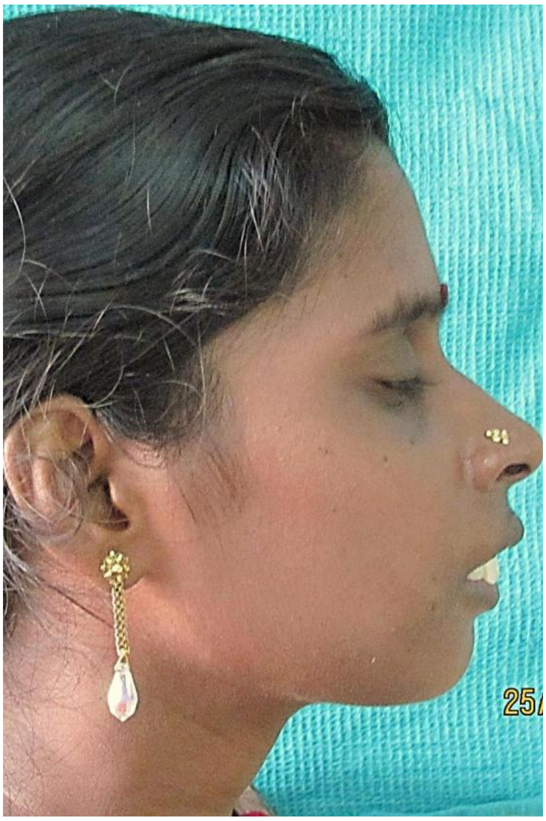
Profile view

Pre-operative

Post-operative

Three Quarter view

Pre-operative



Post-operative

Pre-operative

Post-operative

Frontal view

Pre-operative

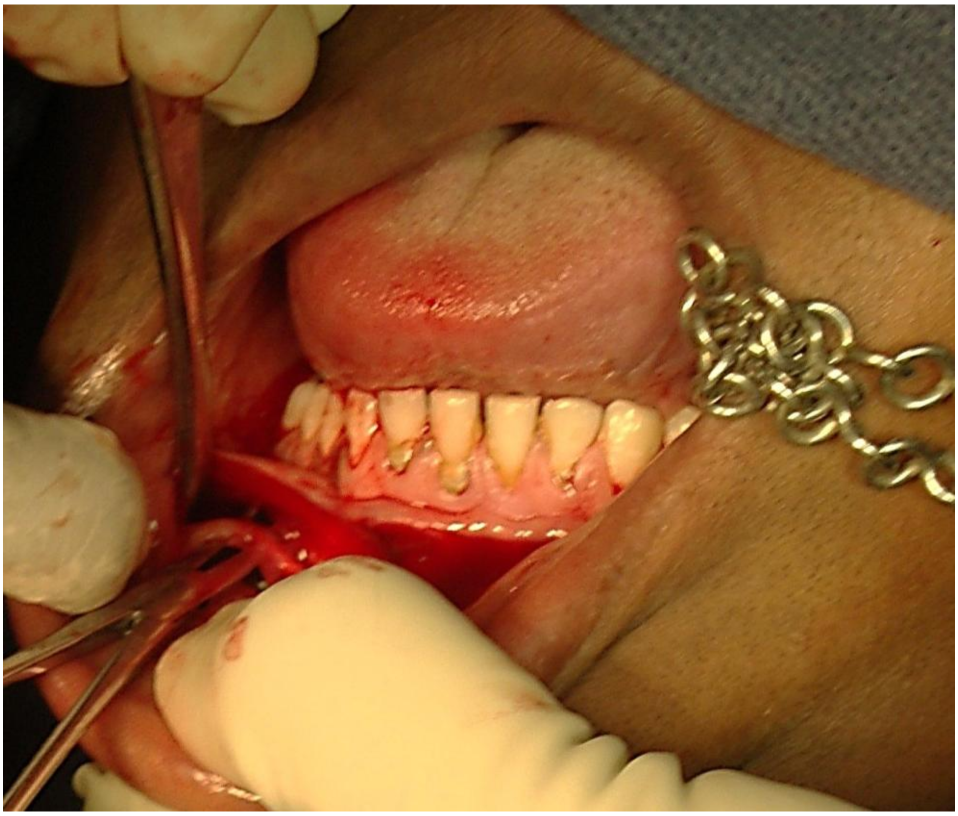
Post-operative

Profile view

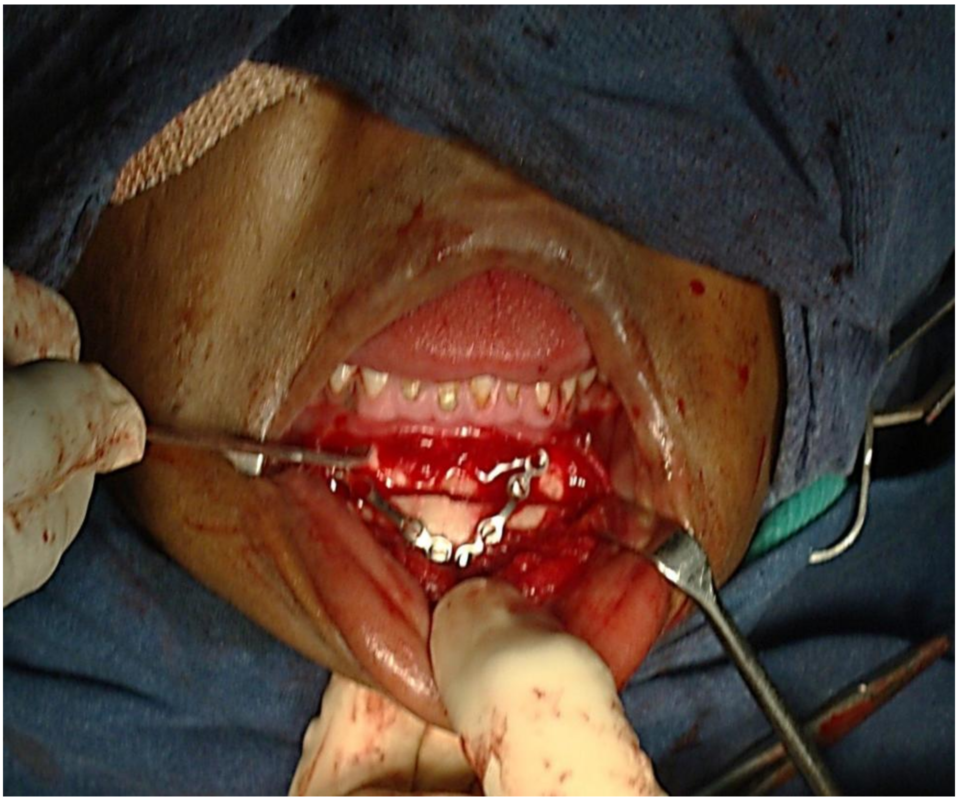
Pre-operative

Post-operative

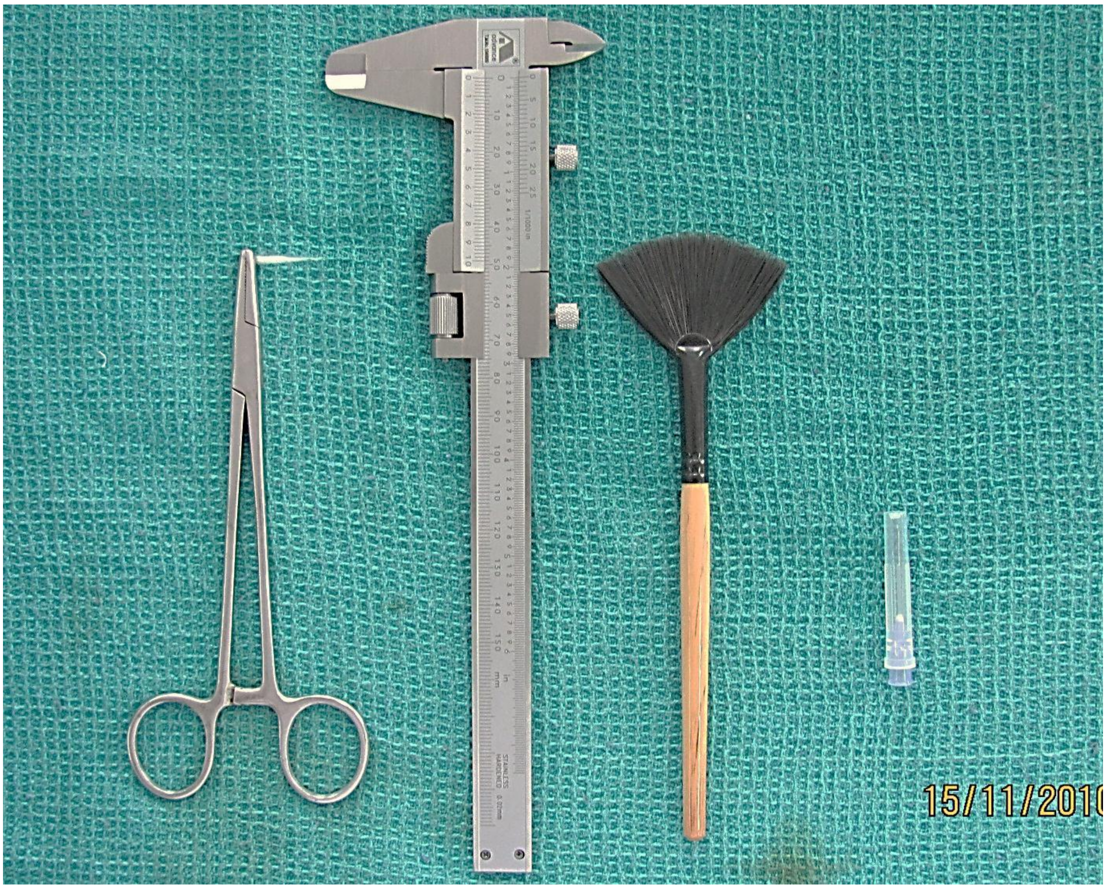
Mental nerve



Rigid Fixation



CNT - Armamentariun



Pulp Tester

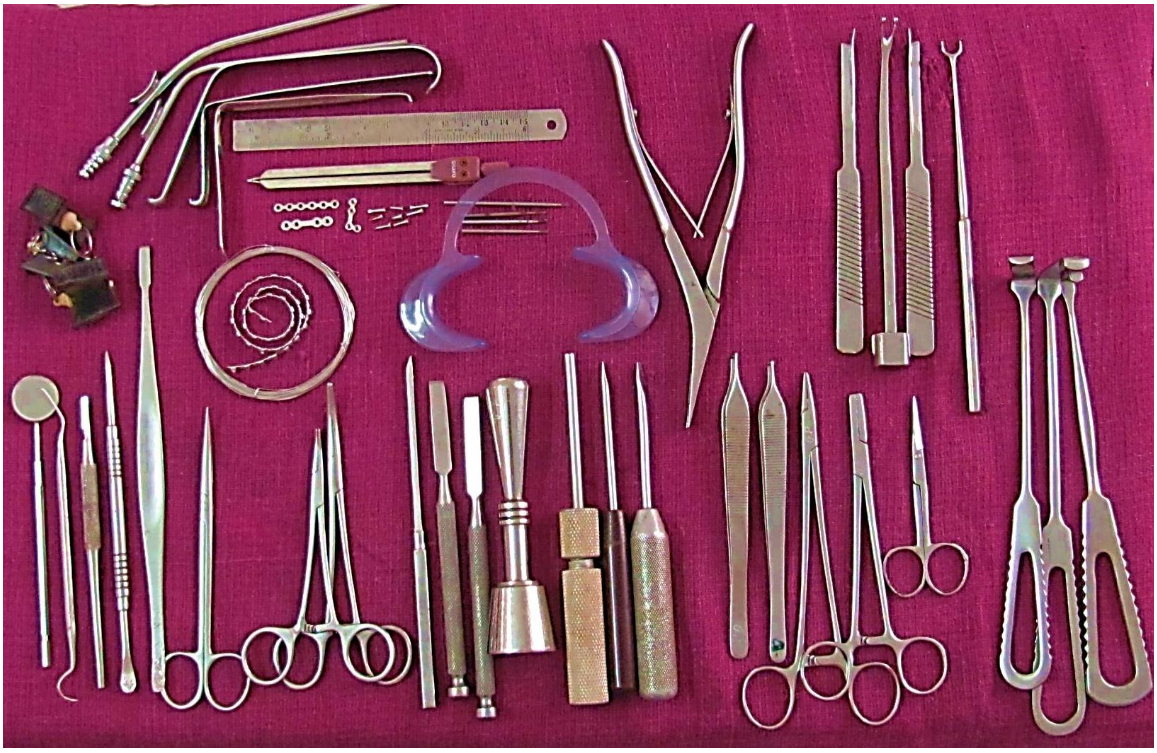
Two point discrimination

Two point discrimination

Static light touch

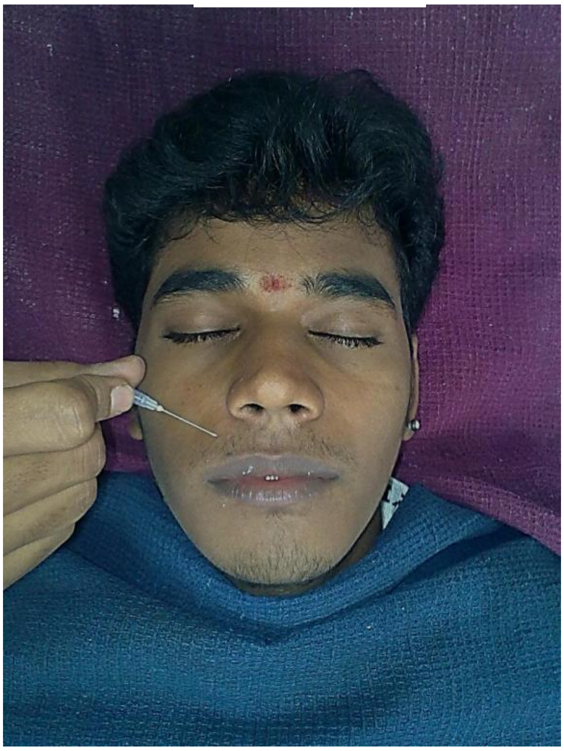
Brush directional stroke

ARMAMENTARIUM

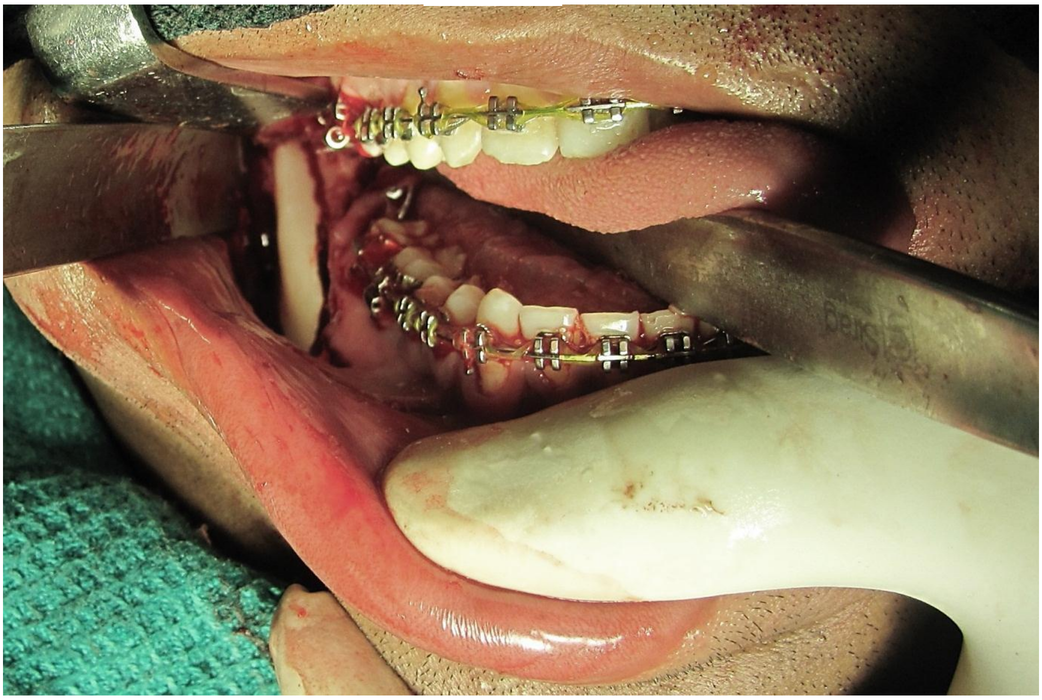


Area of Testing

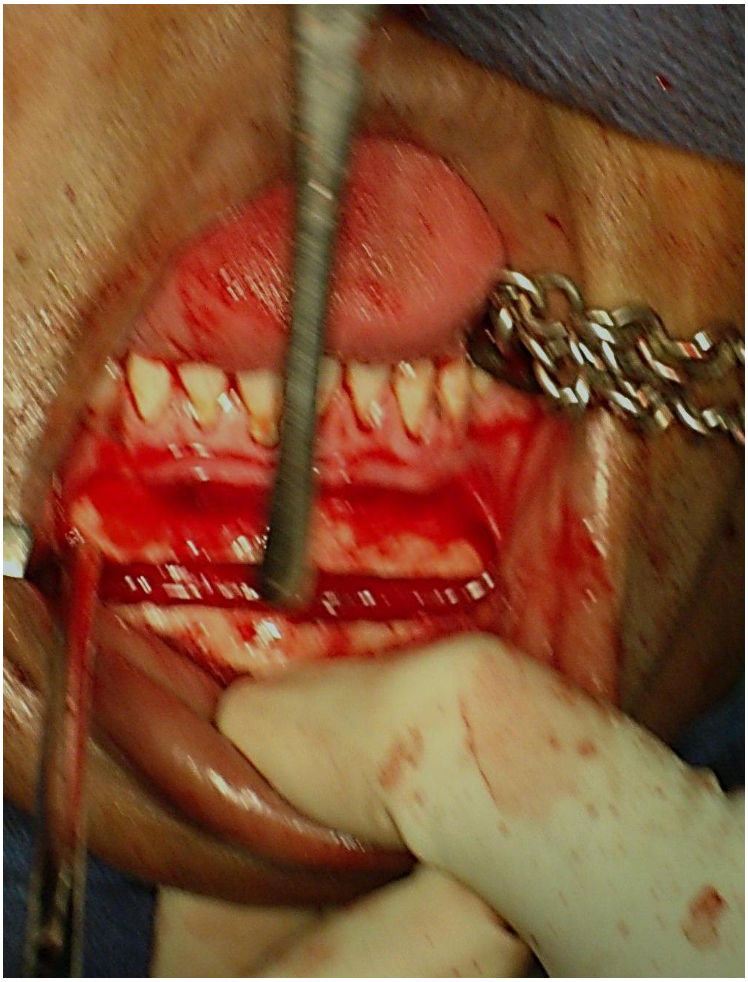
Pin Prick



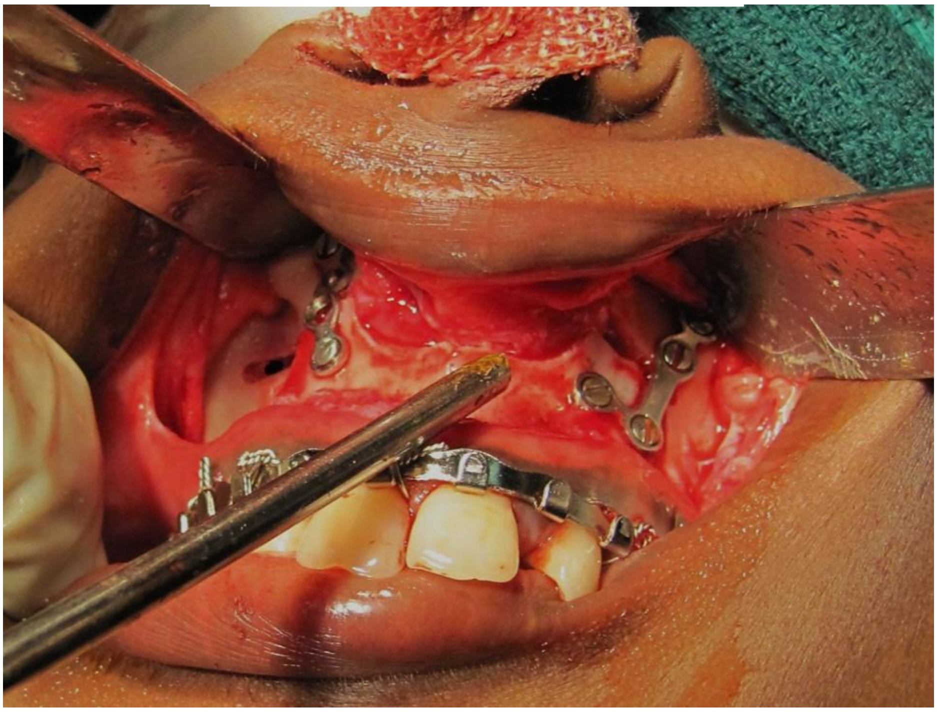
BSSO



Genioplasty



Anterior Maxillary Osteotomy



Lower Subapical Osteotomy